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OFFICE OF EXPERIMENT STATIONS

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REPORT ON THE AGRICULTURAL EXPERIMENT STATIONS, 1950[1]

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STATION RESEARCH OPENS NEW FRONTIERS

During the nineteenth century free land served as a major incentive in settling the American continent. It attracted sturdy, freedom-loving people of rural stock from our settled East and South and from many parts of Europe. After the turn of the century, however, little land was available for distribution by the Government. People then began asking if American agricultural production could keep on expanding.

This query has been conclusively answered during the past 50-year period. Since 1900, American agriculture has demonstrated an amazing productive power. Its constantly developing and advancing farm technology, based to a large extent on agricultural research of the State experiment stations and the United States Department of Agriculture, has become the new frontier.

On the strength of technology the farmers and the Nation's growing population are moving forward together to a higher plane of living. Directly or indirectly the benefits of our agri-

[1] Submitted in accordance with the requirement that the Secretary of Agriculture shall report to Congress on the work and expenditures of the State agricultural experiment stations established under the Hatch Act of 1887 and supplementary legislation. The period covered is the fiscal year ended June 30, 1950.

cultural research are also passed on to people in many lands. Scientific agriculture means a productive agriculture. A productive agriculture means an economically healthy America, and a healthy America can do much toward building a peaceful world.

Today the farmer who combines intelligent planning with practical recommendations developed by agricultural research is steadily increasing the productive capacity of his land. Farming problems vary from year to year, but the farmer who does his job scientifically and puts in the necessary amount of work is on the average growing more and better food and fiber crops on fewer acres than his father was able to grow with less science and a larger acreage.

The 1950 census shows a national population of 150,604,000 people, 18 millions more than the 131,450,000 counted in 1940. Yet American farmers have been able to step up production to more than meet domestic demand. Besides amply supplying domestic needs, they are also producing for food- and fiber-lacking countries abroad.

The present generation knows that this marshaling of scientific knowledge for practical application on the farm has become the key to productivity. Highly trained technical personnel at the State agricultural experiment stations in the 48 states, Alaska, Hawaii, and Puerto Rico, and in the Department provide the leadership for fundamental study. They are closely affiliated with the cooperative extension workers, to whom farmers come with specific problems, and through whom new practices are brought to farmers. The State experiment stations and the Department are sensitive to every major farming problem and respond quickly to each new situation with studies aimed at immediate or long-time solution.

The great progress that farmers have made during and since World War II in the Corn Belt, the Cotton Belt, and in every major farming region is intimately tied up with agricultural research. Much of this progress is the result of many years of research through individual station projects and through cooperative projects carried on between two or more State stations, or between stations and the Department of Agriculture. Regional cooperation among State experiment stations is increasing. The regional program has established a pattern for efficient research procedures between States and has speeded the practical application of scientific findings on the farm.

PLANT BREEDING AND IMPROVEMENT

The trend in agricultural research is also toward closer cooperation in all fields. In this 1950 report on the research at the agricultural experiment stations, the Office of Experiment Stations has selected plant breeding and improvement for major emphasis.

Plant breeding is a field of applied science that has grown up in 50 years to a position of major importance in our national economy. Before the turn of the century, many plant varieties

that happened to do well on one farm or in one community were too readily accepted for general use.

Since 1900 many lifetimes of effort were put into the development of plant breeding as a fundamental contribution to agriculture. Many of the pioneers in this field are still active. For instance, in the spring of 1950 the North Dakota Experiment Station announced retirement, at 85, of the first agriculturist in this country to submit plants to an epidemic disease in order to select disease-resistant varieties. Today this principle is general in all breeding for disease resistance.

The research began in an effort to maintain flax as an important source of oil for paints and other industrial uses. Until the work began, farmers in the Northwest had believed that the decline in flax crops was due to a "wearing out" of the soil. This scientist showed that the decline in yields was due to a soil-borne fungus infection. Once this fact was established, it was possible for the North Dakota station, in cooperation with the Department and much privately financed research, to develop wilt-resistant strains. In 1948, an estimated 25,000,000 bushels of that year's flaxseed crop was grown from varieties developed at numerous State and Federal stations from parent material originally developed by this one scientist. That year's harvest of wilt-resistant flax, at the average value of $5 per bushel, meant $125,000,000 for American industry.

Similar research, which began at the Minnesota station in 1906, could be cited in the development of stem-rust-resistant wheat. The wheat studies were expanded later at numerous State experiment stations and the Department to meet national problems. The bumper wheat crops of World War II could not have been produced without conquest by science of the devastating stem and leaf rust diseases. These diseases have a tendency to develop new races, and science must constantly be on the alert to meet new threats with varietal strains that will be disease-resistant. The effort of the plant breeders must be, therefore, a continuous struggle with nature to enable farmers to produce crops that will be disease-resistant under changing conditions.

Another often-told contribution of the plant breeders is the development of hybrid corn varieties that fit special climatic, soil, and seasonal requirements. In the 1949 crop year, 77.6 percent of the corn acreage in the United States was planted to hybrid corn. The use of hybrid varieties contributed to the high yield of 3,379,436,000 bushels for all corn that year from the 87,029,000 acres harvested. The increase in use of hybrid seed from 0.1 percent in 1933 can be credited largely to research of the State experiment stations and the Department. Development of new hybrid varieties has greatly helped farmers to develop the techniques of choosing and planting the right corn for conditions prevailing in their communities. Practical application has been aided by intensive educational efforts on the part of the cooperative extension services. Surveys show that in the North Central States, hybrids are now being grown on more than 94 percent of the corn acreage.

The principles of scientific plant breeding have been applied to practically every type of plant grown on farms and in gardens. Until experiment stations and breeders undertook to develop plants on a scientific basis, new varieties came into use on a more or less hit-or-miss basis of selection by individual growers. Until the early nineties home gardeners were encouraged to plant potatoes for seed, on the remote chance that they might discover new varieties, but since 1895 no nationally outstanding variety of potatoes has been developed in this way. Development of new and superior varieties is now in the hands of the plant breeders of the State experiment stations and the Department. Closely allied with them in these efforts are the crop-improvement associations and private firms interested in introducing high-quality seed stock.

Garden catalogs late each winter remind the public of the task that perpetually faces the breeders of new vegetables and ornamental plants. Demands are manifold. Novelties in pumpkin or petunia, in collard or calendula, are eagerly sought. A new tomato variety resistant to a pest that might plague our commercial growers or a new kind of garden pea that will maintain high quality under new quick-freezing techniques may be the beginning of a revolutionary change that will have far-reaching effects on the grower, the merchandiser, and the consumer. Each State experiment station, after consideration of all the factors that make the State an agricultural entity, such as its climate, soil, markets, and the demands of its people, includes a program of research to find new varieties of crops that will satisfy the needs of the consumer and further the business interests of the agricultural industries in the State.

Plant breeding, therefore, requires a close research relationship, not only between the agronomists or horticulturists and the geneticists, but also with the entomologists and plant pathologists. And closely associated with all plant-breeding research are the soil scientists, the agricultural engineers, the chemists and biologists, the physicists, and the food technologists.

Practically every branch of science has important contributions toward the fullest development of plants and crops that farmers and gardeners need and want in order to meet the wide variety of soil and climatic conditions in this country. In close cooperation with the scientists are the co-ops and private groups whose business it is to introduce proved varieties to the public, and the county extension agents who, as trained agriculturists in the county, are in a position to work with the research workers in selecting varieties best suited to local requirements.

FIELD CROPS

Breeding new varieties and strains of food, feed, fiber, oil seed, and special-purpose field crops is based on fundamental genetic investigations, and breeding research employs methods and techniques that are being continually improved. The results are carefully appraised by special laboratory tests and extensive field

testing under practical conditions. The new crop varieties, mostly the results of planned research, are high yielding and characterized by superior qualities; are resistant to various diseases and certain insects; can endure climatic extremes and environmental hazards; are adapted to topographical situations; produce plants with types and maturities that adapt them to mechanized production and harvesting; are suitable for storage and handling; and produce plants and products that have special values for food, feed, and manufacturing purposes. The superior new varieties are, in large measure, products of regional and national crop-improvement programs in which groups of State experiment stations and the Department have cooperated in planning, selecting, inbreeding, crossing, and testing over long periods; in building up a supply for distribution and ultimately releasing these varieties to growers through crop-improvement associations. The wheat, corn, oats, barley, rice, cotton, soybeans, peanuts, flax, potato, sweetpotato, and tobacco programs are conspicuous examples of such cooperative efforts.

Corn

Widespread adoption of corn hybrids has resulted from their good performance even in marginal areas and in drought years, their resistance to root- and stalk-rotting diseases and to the corn borer and other insects, their better adaptation for machine cultivation and harvest, and their differing levels of protein and oil contents. Promising hybrid combinations are being brought forward and parent stocks are exchanged for production of additional superior adapted hybrids of good quality by the experiment stations in the several regions cooperating with the Department [2] and other agencies in State and regional corn-improvement programs. Production values of the new hybrids are being determined for farmers through station performance trials of expiremental and commercial hybrids and varieties in nearly every corn-growing section. The trials in the Corn Belt, by the Illinois, Indiana, Iowa, and Ohio stations, for example, have been comprehensive and quite essential to the hybrid corn enterprise in those States.

States bordering the Corn Belt have continued to expand the use of hybrid seed. The largest relative increases are taking place in the Southeastern States, where substantial gains seem probable for the next several years. The North Atlantic and most Western States are also increasing hybrid corn production.

Corn improvement for any State or region is a long and tedious procedure. It is necessary first to develop inbreds that are superior to those currently in use, that are less susceptible to insects and diseases, and that show best response to soil nutrients. For example, the Pennsylvania station developed 103 new hybrids and tested the double crosses in 5 seasonal maturity areas. A number

[2] Hereafter, where the U. S. Department of Agriculture has given assistance in a specific field, that cooperation is indicated by the notation "(coop. USDA)."

of these new hybrids will replace certain hybrids that are now grown but are poorly adapted to their environment and possess yield-reducing defects. In research, complementing the improvement, the station determined crude protein and carotene contents of 22 inbred lines of yellow dent corn in single cross combinations and found that the genetic constitution of corn was largely responsible for its chemical composition, and that, other conditions being the same, different strains of yellow corn vary widely in their nutritive content.

New hybrids in Minnesota, bred for cold resistance, have extended corn as a commercial crop nearly to the Canadian border. Nodak 301, an early yellow dent hybrid made up of lines developed by the Minnesota and North Dakota stations, is designated for the northern corn zone of the State. The Minnesota station also has developed new high combining inbred lines with greater resistance than either parent to the first brood of European corn borer. Minhybrid 408 has shown superior tolerance to the corn borer. Several selections with definite resistance to corn borer at Toledo, Ohio, and also in Minnesota, have shown considerable tolerance to the second brood attack.

New early corn hybrids of the Michigan station—Michigan 26, adapted to north central and south central Michigan, and Michigan 381, adapted to the northern and north central areas—have outyielded several good hybrids widely grown in those areas. The new varieties dry quickly in the field and have a relatively low moisture content at harvest.

Three new Wisconsin hybrids illustrate the fact that future advances in corn improvement are likely to be refinements in particular characters rather than spectacular increases in yield, as in the past. W207, 85-day maturity, is easy to husk and has good stalk qualities for mechanical picking. W341A, 90-day maturity, half related to the 90-day W341 and W355, is highly rated for spring cold tolerance and has improved stalk and husking qualities, with very compact, heavy ears. W464A, 100-day maturity, resembles the widely popular W464 in yield and pedigree but has improved stalk qualities, shows less breaking, husks easier and cleaner, has open husks, has drooping ears as maturity approaches, and has a good spring cold-tolerance rating.

Of six new Ohio station hybrids certified for farm use in 1950, Ohio K14, K16, K25, K43, comparable in earliness with K24 and K35, do not outyield the older hybrids but are better suited for mechanical harvest. Ohio W46, comparable in maturity with W36, is resistant although not immune to leaf blight and to the first generation of the European corn borer. Ohio C47, slightly later than C38, is higher yielding, better suited to mechanical harvest, more resistant to European corn borer, but is no more susceptible to leaf blight.

Nebraska 801-W, the first white hybrid corn to be released by the Nebraska station, has outyielded other white and yellow hybrids in State-wide tests. Its husks open as the plants mature, which facilitates drying and picking. It is adapted to southeastern Nebraska. An earlier white hybrid (Nebr. Experimental

5059A) appears well-adapted to central and southwestern Nebraska.

Two new hybrids developed by the Tennessee station (coop. USDA) have excellent performance records in Tennessee, North Carolina, Mississippi, and Georgia. Dixie 22, a full-season semiprolific yellow hybrid, has outyielded all other yellow hybrids in tests, and surpasses Dixie 17 and Tennessee 602 in husk rating and percentage of best plants. Dixie 33, a full-season white hybrid, stands and picks well and its good husks provide extra protection against insects and weather damage.

Georgia 101, a white early hybrid released by the Georgia station (coop. USDA) and outstanding in the State, also is high yielding in Alabama, North Carolina, and Tennessee. It has a medium-hard grain and is recommended for cut corn in northern Georgia and for hogging-off in southern Georgia. Hybrid corns (Tennessee 10 and Dixie 17) in the station's experiments have produced meal as acceptable for use in corn bread as meal from common open-pollinated varieties. This finding contradicts complaints of inferiority of corn hybrids for meal and corn bread.

State-wide tests of the new Texas station hybrids 24, 26, and 28 show that they may produce from 5 to 10 percent more corn per acre than other hybrids now available. Texas 26 and 28 have done particularly well in the blackland prairie, and western corn-growing regions, whereas Texas 20 and 28 gave the highest yields in east Texas. Texas 28 appears to be the most widely adapted of these new hybrids, although Texas 24 is definitely superior in resistance to root lodging and also suffers less earworm damage.

Dixie 18, the top yellow hybrid in Louisiana tests, has erect stalks and good husks, makes high yields, and is adapted to south Louisiana and the alluvial soils of the Mississippi and Red Rivers. It was released for production by the Georgia Coastal Plain station and the Department. La. 521, a white hybrid released recently, continues to make top yields in south Louisiana. Although Florida W–1 continues in demand where weevil resistance is of great importance, the Florida station reports that this hybrid is rapidly being replaced by Dixie 18 which is higher yielding and more resistant to lodging.

Wheat

New and better varieties of wheat developed by the specialists of the experiment stations and the Department in their several regional wheat-improvement programs ultimately replace the older sorts. The improved wheats have high acre yields or such characteristics as adaptation to locality, resistance to both long-established and recently-found plant diseases, endurance of severe winter conditions, suitability for mechanized production and combine harvesting, or definite superiority in milling and baking, pastry, or macaroni values.

Plant breeders have encountered many difficulties in their efforts to breed all desired characteristics into single varieties of wheat for different environments. The breeding work is comple-

mented by nursery, varietal, and cultural tests, plant-disease studies, and milling and baking determinations. After exhaustive appraisals to locate their best places in American farm economy, these new wheat varieties are multiplied and distributed to growers through crop-improvement associations and similar agencies.

The wheat varieties developed and released by the experiment stations in cooperation with the Department and sown on vast acreages contributing to the billion bushel wheat crops of recent years include Pawnee, Comanche, Wichita, Tenmarq, Westar, Cheyenne, Nebred, Kanred, and a number of strains of Turkey among the hard red winter class, adapted to the southern half of the Great Plains region. Wasatch is one of the more recent varieties in this class that is grown in the intermountain region. The acreages of hard red spring wheat, grown in the North Central States, are increasingly sown with improved varieties as Mida, Thatcher, Rival, Pilot, Vesta, and Cadet, all products of the cooperative breeding program. Stewart, Mindum, Pentad, Carleton, and Vernum are new durum wheats of merit. Thorne, Trumbull, and Kawvale, established improved varieties of soft red winter wheat, grown largely in the Eastern States, are being supplemented in production by the newer cooperative productions such as Vigo, Austin, Seabreeze, Wabash, Fairfield, Sanford, Chancellor, Leapland, and Butler. Station research with white wheats, grown in the far West and also in Northeastern States, has resulted in such productive and superior varieties as Yorkwin, Elgin, Rex, White Federation 38, and Baart 38.

Quanah, said to be the first stem-rust-resistant variety of hard red winter wheat for the southern Great Plains, is being made available to Texas farmers. Developed by the Texas station and the Department, Quanah resembles Comanche in general appearance and time of maturity in test weight of grain, and milling and baking characteristics, and produces flour of good quality for commercial baking purposes. Compared to Comanche it has a shorter, stronger straw, is equal in bunt resistance, superior in leaf-rust resistance, and also is resistant to stem rust. Quanah is recommended to replace stem-rust-susceptible varieties in central Texas and also for the rolling plains area, particularly in the southern part.

Minter, a new hard winter wheat with moderate resistance to stem rust developed by the Minnesota station (coop. USDA) and the South Dakota station, combines the stem-rust resistance of Hope and the productivity and winter hardiness of Minturki, its parents. Minter has a higher test weight and water absorption than the presently grown varieties, such as Minturki and Marmin. It has a lower content of yellow pigment, and thus produces a whiter flour and whiter crumb in the bread loaf.

Nugget, a new durum wheat, bred to assure macaroni manufacturers of a more desirable, deep yellow product, was released in 1950 by the North Dakota station (coop. USDA). This new, short-stemmed macaroni variety ripens almost as early as bread wheat and is adapted to southern North Dakota.

Two new stiff-strawed, smut-resistant winter wheats, Elmar and Brevor, developed by the Washington station (coop. USDA) are both short-strawed, winter-hardy, soft varieties which made excellent pastry flours. Elmar is essentially an Elgin wheat with the smut resistance of Hymar added by backcrossing. Brevor, a beardless common wheat with white chaff, has the combined resistance to bunt of Oro and Ridit. Both varieties have outyielded currently grown wheats by from 10 to 15 percent and are adapted to Pacific Northwest winter wheat areas.

Atlas wheat (strains 50 and 66), developed by the North Carolina station (coop. USDA) has shown great promise in tests in North Carolina and in adjacent States. Adapted to Coastal Plain and Piedmont areas, these strains have a semiwinter growth habit, ripen about one week later than Redhart, have exceptionally stiff straw, normally stand well for combining, and have compact heads slightly spreading toward the tip. Atlas 50 has shown good resistance to powdery mildew and fair resistance to leaf rust, and Atlas 66 excellent leaf rust resistance and fair mildew resistance. Both strains possess satisfactory milling and baking quality as soft red winter wheats. Yields have averaged about 32 bushels per acre compared to 22 bushels for Redhart and 30 bushels for Hardired.

Oats

Oats breeders of the experiment stations and the Department working under coordinated programs have provided American farmers during many years with new, productive, smut- and rust-resistant, stiff-strawed, or winter-hardy varieties. These have desirable kernel characters and are adapted to the varied environments and cultural practices (including irrigation) of the north central, central, northeastern, southern, Great Plains, Rocky Mountain, and Pacific Coast oats regions. The rapid conversion by farmers from the older varieties to new varieties resistant to smuts and rusts is evident in the increasing volume of the national oats crop that is now approaching 1.5 billion bushels annually.

Results in Iowa are especially worthy of note. The Iowa station estimates that the oat breeding research from 1941 to 1949, carried on cooperatively with the Department of Agriculture, netted Iowa farmers a gain of $113,540,255. Tama, Boone, and Control oats, rust- and smut-resistant varieties, have in their parentage Victoria, a South American introduction resistant to crown rust and also to smuts. These Victoria derivatives distributed to Iowa farmers in 1941, were being grown on more than 90 percent of the Iowa oats acreage by 1945. Victoria and these derivatives were found susceptible to a new and very destructive species of blight (*Helminthosporium victoriae*), which appeared in 1944. Fortunately, the development of new varieties less susceptible to crown and stem rusts was then well under way. These also were resistant to Victoria blight through crossing on the Bond variety, introduced from Australia.

Clinton, currently the most widely grown oats, and 11 or more other named Bond derivatives have been distributed in many States. Shelby, another new productive, stiff-strawed oats, is being increased for release in 1951. It combines most good points of its parents (Bond and Anthony) which have high quality grain and test weight. Shelby is more resistant to smuts and more uniform in height and maturity than Clinton. Although Shelby is not entirely resistance to race 45 of crown rust, its yields have not been lowered much by that disease.

Kent, a new early disease-resistant oats and a sister strain of Clinton and Benton, is a joint product of the Michigan and Iowa stations (coop. USDA). It is designated for the "Thumb" and Saginaw Valley of Michigan but probably is adapted to other parts of the Lower Peninsula where lodging has not been a serious limiting factor. It is high-yielding, has white grains with high test weight and a medium-stiff straw, and grows about as high as Eaton. Kent is resistant to the more common races of stem and crown rust, except race 45 and similar races of crown rust that occur in Michigan, and also is resistant to many races of the oat smuts and to Victoria blight.

James, a new mid-early, stiff-strawed hull-less oats and a desirable swine and poultry feed, has been released by the South Dakota station. It has produced a high yield of good quality grain in eastern South Dakota. Resistant to both species of smut, James has the White Russian type of stem-rust resistance and Bond type of leaf-rust resistance.

Mustang, a new oats about 25 percent more winter hardy than commercial varieties commonly grown in Texas, has been released by the Texas station (coop. USDA). It is resistant to crown rust and shows considerable tolerance to Victoria blight, whereas its early maturity usually enables it to escape stem rust. It has short strong straw and stands well for combine harvesting. Mustang produces less fall pasture than Red Rustproof strains but more in midwinter and early spring when pasture is most needed for grazing.

Arlington and Atlantic oats, selected by the Department and increased and distributed by the Georgia, North Carolina, Virginia, and Kentucky stations, are productive, early maturing, tall, and reasonably stiff-strawed, with large plump yellow kernels of good test weight. They approach Lee in winter hardiness, and have good resistance to ordinary races of crown rust and to mosaic, and appear more promising for forage or winter pasturage than the Lee-Victoria varieties, such as Letoria, Lelina, De-Sota, and the Stanton strains. Additional new disease-resistant varieties are anticipated from crosses between Atlantic and sister strains with other oats resistant to Victoria blight, crown rust race 45, stem rust races 8 and 10, and the ordinary rust races.

Barley

New barleys released to farmers by the experiment stations and the Department from their Nation-wide cooperative improvement projects, have such noteworthy features as high yields and

smooth awns and in addition, are resistant to diseases, have improved winter hardiness, stand better, and retain heads after ripening.

Moore barley selected by the Wisconsin station (coop. USDA) is a white six-rowed, smooth-awned variety of medium height and late maturity. It is desirable for combining, and has a stiffer straw than currently grown malting varieties and outyields them. It is moderately resistant to stem rust, mildew, and spot blotch. Its malting qualities are satisfactory. The station reports that Moore is rapidly replacing certain of the older varieties because of good yields, standing and threshing qualities, and greater disease resistance.

Erie, a new two-rowed, spring barley released by the New York (Cornell) station (coop. USDA) is resistant to powdery mildew, has smooth awns, and shows a gain of about 3 bushels per acre over Alpha, currently the standard variety.

Colonial, a productive winter barley developed by the North Carolina station, has been superior in several respects to other varieties now grown in the State. It is six-rowed, practically beardless, has a short stiff straw, stands much better than Sunrise for combining, is somewhat more winter-hardy, resists some but not all local races of powdery mildew, and has some tolerance to leaf rust. In tests from Maryland through Georgia, Colonial has averaged 46.4 bushels per acre compared to 29.4 bushels for Sunrise.

Harbine, a new six-rowed winter barley with outstanding resistance to lodging, developed by the Oklahoma station (coop. USDA) has a short, stiff straw suitable for combine harvesting, has a high test weight, threshes relatively free from beards, carries considerable resistance to leaf rust, and has some resistance to several other leaf diseases. Harbine is resistant to five of the eight races of loose smut. It is about equal in winter hardiness to Tenkow, widely grown in Oklahoma, but is not so winter-hardy as Ward. The slightly higher yield of Tenkow is offset in measure by the smaller proportion of beards found in threshed Harbine.

Improved Arivat, a superior strain of the well-known Arivat (first released in Arizona in 1940 and widely grown in Arizona and California) differs primarily from the parent variety in that it yields more grain—76 bushels per acre—compared to 71.9 bushels for Arivat. Improved Arivat developed by the Arizona station (coop. USDA) can be substituted for Arivat with few adjustments, for they differ little in characters other than yield.

Bonneville, a new spring barley with stiff straw, club heads, and smooth awns, bred by the Utah station (coop. USDA) has been released for seed production in Oregon and Utah. Bonneville has made the highest yields of any barley tested in Utah. In tests in the western United States and Canada, it outyielded Velvon barley by about 20 percent. It is especially adapted to fertile irrigated lands in areas with a fairly long season.

Spray, a new six-rowed, hooded barley that resembles Meloy but has more leaves and finer stems and heads slightly earlier,

was developed by the Oregon station (coop. USDA). Released for hay production in Wheeler County, Oreg., and the immediate area, Spray is an improved spring barley variety for both grain and hay.

Rice

The recent definite shift to better rice varieties has been hastened by the use of adapted improved varieties which are being developed and released by the Louisiana, Arkansas, Texas, and California stations (coop. USDA).

Zenith, Colusa, Prelude, Magnolia, and Cody of the early group; Calora, Calrose, Fortuna, Bluebonnet, Rexark, and Arkrose, mid-season; and Blue Rose 41, Rexora, and Texas Patna of the late group are station accomplishments. They are very productive under suitable conditions. In 1949, more than 90 percent of the rice fields in the United States were sown with these and other improved varieties.

Lacrosse 250, a new early rice variety developed and released by the Louisiana station (coop. USDA) is outstanding in yield and strength of straw. Although the tightly attached grain does not shatter in harvesting with a binder, it combines very satisfactorily.

Sorghum

The sorghum breeders of the stations in the Great Plains and the Department have developed and released a number of superior varieties that are extensively grown in the main sorghum areas and are proving acceptable for both farm and industrial use. These new varieties are the result of basic research on the genetics of the sorghum in relation to the inheritance of economic plant and seed characters and resistance to diseases such as Periconia root rot and charcoal rot, and to insects, particularly chinch bugs.

Improved grain sorghums already brought out and distributed by the Texas station (coop. USDA) include Plainsman, Caprock, Dalhart Wheatland, Combine Kafir, Texas milo, Texas Double Dwarf milo, Milo 7088 (chinch-bug resistant), Quadroon (resistant), and Bonita or Early Hegari. All of these are resistant to Periconia root rot and most of them are suitable for combining. Sweet Sudan Grass, a select pasture and hay crop, is another valuable product of this breeding program.

Millions of bushels of grain and more forage and silage are expected from four new sorghums recently developed and released by the Texas station (coop. USDA). Combine Kafir-60, a high-yielding pure Blackhull kafir type of double dwarf height and adapted to combining, has white seed and juicy stalks, stands up well in the field, and is relatively early. Redbine-60 and Redbine-66, new red-seeded combine varieties can be harvested before frost and have long peduncles which facilitate combining because they have less leaves and stalk to load down the shakers. Both have a seed of brighter reddish-yellow color than Martin, and have longer peduncles, are taller, and thresh better than Plains-

man. Redbine-60 because of earliness is more certain in production, whereas Redbine-66 yields higher under favorable conditions because of its longer growing season. Hi-Hegari, a tall variety of hegari with the same maturity and adaptation, yields about 20 percent more forage or silage.

Pop-sorghum, brought out by the Texas station, has improved popping qualities resembling those of popcorn and is adapted to the Sorghum Belt. Its puffed kernels are more tender than popcorn because the hull is thinner, there is less husk to lodge between the teeth, and they are said to be as palatable and nutritious as popcorn. Besides substituting for popcorn in sorghum regions, pop-sorghum has potential use in candied or caramel confections, popped or puffed sorghum for breakfast cereal, and for flour or meal.

Productive sorghums released to Oklahoma farmers by the Oklahoma station (coop. USDA) are Wheatland, Beaver, and Sooner Milo. Some newer types are Dwarf Kafir 44–14, a short stalk combine variety, and Kaferita 811, a pure white seeded sorghum. Use of these chinch-bug-resistant sorghums in central and eastern Oklahoma provides stockmen with more reliable grain sources and cotton and wheat growers with another cash crop to be harvested with mechanical equipment. Sumac 1712 is a promising drought-enduring home-sirup variety with high forage yields. A new Honey sorgo strain, chinch-bug resistant, and 10 days earlier than ordinary Honey, has given good sirup yields even when ordinary strains are leveled by chinch bug. Redlan Kafir, a new dwarf combine variety adapted to the High Plains, is featured by a head that dries rapidly to a low moisture content at harvest. Redlan has averaged 30 bushels of grain per acre, and outyields several popular combine sorghums in field tests. It is sweet in taste, blackens less than ordinary sorghum in rainy weather, and has fair resistance to lodging, insects, and disease.

The Kansas station has given Plains farmers such high yielding and useful sorghums as Westland, Midland, Early Kalo, and Cody (a waxy-starch type), and Atlas Sorgo. Ellis sorgo, developed by the station (coop. USDA), has a sweet juicy stalk, high in sugar content, and leaves resistant to bacterial leaf spot. It provides palatable silage or bundle feed and the grain is waxy and suitable for processing.

Norghum, an early, open-panicled combine grain sorghum that usually matures before frost for early harvest, and is adapted to all parts of South Dakota, is a South Dakota station production. The rapid germinability of its reddish-brown seed at low temperatures is important in obtaining stands in early plantings and under unfavorable growing conditions. Norghum has proved palatable to lambs which made daily gains equal to lambs on shelled corn. Rancher, a widely grown earlier development of the South Dakota station is a good-yielding, early forage variety. It is said to have the lowest hydrocyanic acid content of any named forage variety in the production—only about one-tenth the amount in commercial varieties.

Cotton

Better cottons are being developed and further improvements made on currently grown varieties by the experiment stations and the Department. Cotton breeding is based increasingly on findings in fundamental research in cotton genetics and closely related fields. Breeders are seeking high-yielding varieties with superior fiber and spinning qualities, which have plant and boll characters adapted to machine cultivation and harvest. The new cottons possess resistance to diseases such as fusarium and verticilium wilt and bacterial blight. They are suitable for growing in humid areas, under irrigation, on dry land, and in different latitudes.

Some of the more recent widely grown and promising varieties and strains developed by the experiment stations and the Department are Arkot 2–1 by the Arkansas station; Acala 25 and 44 by the Arizona station; and Acala 1517W and 1517A and 1517B by the New Mexico station; Acala 4–42 (coop. USDA) in California; Plains by the Alabama station; Empire by the Georgia station; Pandora by the Georgia Coastal Plain station; Stoneville 62 by the Oklahoma station; Sealand 542 by the South Caroline, Georgia, and Florida stations; Tennessee 241 by the Tennessee station; and Stormproof #1 by the Texas station.

Soybeans

The quick adoption by farmers of the superior varieties of soybeans developed by the experiment stations with the Department, together with their use of more efficient cultural and harvesting methods, improved storage and handling practices, and the better utilization of the crop resulting from other research investigations, have been largely responsible for the rapid expansion of soybean acreage and production. Acreage rose from 1,782,000 acres in 1924 to an estimated 13,291,000 harvested acres in 1950 which produced an estimated 287,010,000 bushels of beans.

Growers have been prompt to shift to the newer high-yielding soybean varieties, which are also high in oil content and are resistant to shattering, lodging, and diseases, and are suitable for mechanized production and harvesting. Prominent among the varieties grown extensively in the Corn Belt, the area of greatest soybean production, and developed cooperatively by the respective stations in the Corn Belt States are Lincoln, Chief, and Viking by the Illinois station; Earlyana, Gibson, Patoka, and Wabash, by Indiana; Adams, Hawkeye, and Blackhawk, by Iowa; Monroe, by Ohio; and S–100 by the Missouri station. Soybean varieties released by stations in the South include Arksoy, Arkansas; Gatan, Georgia; Pelican, L. Z., and Avoyelles, Louisiana; Roanoke, North Carolina; and Ogden and Volstate, by the Tennessee station. Soybean varieties with superior qualities soon are grown far beyond the States of first release.

Peanuts

Peanuts are an increasingly important source of food, vegetable oil, protein feed, and forage. The varieties of merit developed by the experiment stations include Holland Jumbo, a peanut with extra large kernels for salting and confectionery, and Holland Virginia Runner, with short and thick kernels for peanut butter and oil, both (coop. USDA) from the Virginia station. Martin County Runner, produced by the North Carolina station, outyielded Virginia Bunch in northeastern North Carolina. Dixie Runner, a productive peanut for late hog feed, surpassing commonly grown southeastern runners in yield of sound seed and in seed quality, was developed by the Florida station. Spanish varieities with superior productiveness include Spanish 146, 205, and 207–3 of the Georgia station; Spanish 18–38 and Improved Spanish 2–B of the South Carolina station (coop. USDA); and McSpan of the Texas station. The Georgia station (coop. USDA) also has released North Carolina Runner 56–15, which surpasses commercial strains in yielding ability, and Virginia Bunch 67, a small-seeded strain more widely adapted than large-seeded strains, a consistently high yielder wherever planted in Georgia.

Seed flax

Features of the better seed flaxes, developed and released to growers, are high acre yields of good-sized seeds and improved contents of oil high in iodine number (index of drying quality); their vigorous growth and strong straw with good fiber quality suitable for new industrial uses; and their tolerance to chemical weed sprays, resistance to wilt, rust, and anthracnose, and good tolerance to pasmo. The breeding work among the State stations and the Department proceeds in close association with chemical research on oil quality. Prominent among the improved flaxes are Bison, Koto, Renew, Victory, Viking, Dakota, and Sheyenne, by the North Dakota station; Redwing, Biwing, Crystal, Redson, and Minerva, by the Minnesota station; Arrow, by the Montana station; and Rio, by the Texas station.

Potatoes

New potato varieties developed and introduced in the National Potato Breeding Program, a cooperative undertaking of the experiment stations and the Department, provided about 55 percent of the 1949 supply of 48,423,628 bushels of U. S. certified potato seed. The production of Katahdin, the first of the more than 40 improved potatoes to be released to growers by these cooperators —about 17 years ago—was reported at 15,862,075 bushels of certified seed. This represents about one-third of the total of U. S. certified seed potatoes and approaches the combined production of Triumph 5,626,477, Irish Cobbler 5,471,185, and Chippewa 5,187,165 bushels.

Other new varieties brought out in the program, in addition to Katahdin and Chippewa, which also have produced consider-

able amounts of quality seed, include Pontiac, Dakota Chief, Sebago, Teton, Red Warba, Sequoia, Essex, Mohawk, Progress, Russet Sebago, and Houma. A number of these varieties are also widely planted for seed in Canada. The improved varieties are noted for such characteristics as higher yields, superior color and flesh, table and market quality, or adaptation to season and region, and varying immunity from or tolerance to diseases and resistance to insects.

Yampa, a new high-yielding, productive potato, developed by the Colorado station (coop. USDA) and released recently shows high resistance to scab, appears best adapted to lighter soils, matures 7 to 10 days later than Bliss Triumph, and has round to blocky tubers with shallow eyes. It is classed as "white" in the market. Its tough skin reduces "skinning" during harvest, it keeps well in storage, and its cooking quality is well above average. White Cloud, a new early white potato developed by the Nebraska station produces uniform shallow-eyed tubers with high specific gravity and is good for baking. It may serve as a possible substitute where the oversize and rough tubers of Cobbler are objectionable.

Sweetpotatoes

Cooperative efforts among experiment stations in sweetpotato-growing States and the Department have resulted in better varieties for human food, for livestock feed, and for manufacture of starch and other products. Participants in the breeding program are seeking a high content of carotene, desirable flesh color, good shape, superior keeping and canning qualities, and resistance to diseases.

Noteworthy among varieties developed in breeding research at the Louisiana station are Unit I Porto Rico, a leading sweetpotato in the United States, noted for table quality and high content of carotene; Ranger, a variety with flesh-colored skin and bright-orange flesh, and now grown to some extent in the northern United States; Queen Mary, a uniform variety with one-third more carotene than Unit I Porto Rico; and Pelican Processor, a leading feed and starch variety, resistant to wilt and readily accepted for industrial use. Whitestar, released by the Alabama, Mississippi, Georgia, Louisiana, and Texas stations and the Department is another starch type, and is adapted somewhat farther north than Pelican Processor.

Australian Canner, released by the Mississippi station (coop. USDA) retains its shape in canning and the canned product has an attractive uniform orange-flesh color. Texas Porto Rico, a Texas station selection, has outyielded Unit I and other strains of Porto Rico. Jersey Orange, selected by the New Jersey station from Orange Little Stem of the Kansas station, equals Yellow Jersey in agronomic characters, but is moister and has a much deeper orange flesh color, that is retained in cooking. It was introduced to enable farmers to compete with "yam" types offered on local markets rather than to replace Yellow Jersey.

Four of the newest varieties are very promising. Allgold, a gold-skinned, high-carotene sweetpotato for table use, developed by the Oklahoma station, has yielded at nearly double the rate of Porto Rico which it equals in flavor and table appearance, but contains 50 percent more vitamin C and more than three times as much vitamin A. The flesh is bright salmon in color, remains bright when cooked, and when baked is sweet, moist, and a little firmer than the flesh of Porto Rico. The roots keep well in storage and produce plenty of slips when bedded. Allgold has shown resistance to stem rot. Hartogold, a sweetpotato of the Nancy Hall type with a flesh-colored skin and yellow flesh, released by the Louisiana station primarily because of earliness and high yield, can be marketed 10 to 14 days sooner than Unit I Porto Rico. It has shown a high degree of resistance to soil rot. Goldrush, a high-yielding Louisiana seedling has an exceptionally good shape and twice the carotene content of Unit I Porto Rico and is an excellent canning variety. Furthermore, it is highly resistant to wilt and moderately so to soil rot. Virginian, a smooth and glossy early maturing variety released by the Virginia Truck Experiment Station, equals or surpasses good Porto Rico strains, has more uniform orange flesh, and is sweeter and juicier when cooked.

Tobacco

American tobacco breeders have aimed at varieties of each major type with superior leaf and other plant characters, uniformity, appropriate burn and aroma, and resistance to fusarium wilt, bacterial (Granville) wilt, black shank, root rots, and mosaic. The experiment stations in the several tobacco areas and the Department, long working together to attain these objectives, have developed a number of improved tobaccos that have been returning increased profits to growers.

Tobaccos bred by the Kentucky station have been highly profitable to growers. Ky. 16 and Ky. 41 are Burleys resistant to blackroot rot; Ky. 52 and Ky. 48 are Burleys resistant to both black root rot and mosaic; Ky. 33, a stand-up Burley is resistant to black and brown root rots and fusarium wilt; and Ky. 120 and Ky. 134 are dark fire-cured tobaccos resistant to black root rot. Ky. 52 Burley, Ky. 150 dark fire-cured, and Ky. 160 one sucker, all mosaic resistant, have been readily accepted by the trade. The station also has had marked success in developing strains low in nicotine.

Connecticut 15, a shade (cigar leaf) tobacco developed by the Connecticut Agricultural Experiment Station at New Haven and showing marked resistance to black root rot, surpasses ordinary shade strains in many other respects. Havana 142, a cigar leaf tobacco resistant to black root, developed by the Wisconsin station, is very popular among growers in Wisconsin. The Massachusetts station has developed strains of Havana seed tobacco highly resistant to black root rot and acceptable to farmers for plant type and yield and to cigar manufacturers for type and

quality of leaf. These strains are grown on at least 90 percent of the total Havana seed acreage. Definitely superior to common Havana seed tobacco, the new strains return better profits to growers.

Three new varieties of flue-cured tobacco resistant to Granville wilt and black shank are released to farmers by the North Carolina station and the Department. Dixie Bright 27, resistant to Granville wilt, is an improvement over the current wilt-resistant variety Oxford 26. It yields more and has a larger yet less brittle leaf and shorter growth habit. Dixie Bright 101, which has high wilt resistance and moderate black shank resistance, is as tall as Oxford 26 and produces large, broad, and well-proportioned leaves spaced widely on the stalk. Dixie Bright 27 averaged $726 per acre in 1949 and Dixie Bright 101 $751 compared to $549 for Oxford 26. Dixie Bright 102 has excellent quality combined with high resistance to Granville wilt and black shank and larger and thinner leaves than Oxford 26, but it yields less than the other new varieties.

Burley 1, a new disease-resistant, high-quality variety developed by the Tennessee station and the Department, combines root rot resistance and fine textured, thin-bodied leaf structure with production of about seven more leaves per plant than standard varieties. Topping in the bud or early flowering stages permits from three to five of these extra leaves to be harvested. Burley 1 has yielded as well as the most popular standard variety and where the latter produced 30 percent of noncigarette grade of heavy red leaf, the new Burley 1 had only 21 percent of poor leaf, which represented a money gain of about 8 percent an acre.

Vamorr 48 and Vamorr 50, new varieties of flue-cured tobacco produced by the Virginia station, have high levels of resistance to root rot and mosaic as their main advantage over established varieties. They resemble Yellow Special (a high-yielding, flue-cured tobacco, moderately resistant to root rot, released several years before) in field appearance; they yield about as well as Yellow Special in the absence of root rot and mosaic, and are superior in the presence of these diseases. Vamorr 48 plants grow slightly smaller and the upper leaves stand up straighter than those of Vamorr 50. Vamorr 50 has yielded more pounds of leaf, an advantage partially offset by better quality leaf from Vamorr 48. Virginia 111, a new Burley developed for resistance to mosaic and root rot diseases, has proved superior in yield and quality to Ky. 16, one of the two main Burley types now grown in Virginia.

Another destructive disease that has spread into many important tobacco areas and once threatened to wipe out tobacco growing in the South is black shank disease, caused by the soil-borne fungus *Phytophthora parasitica* (Dast.) var. *nicotianae*, which has been successfully held in check only by the development of resistant varieties. The Virginia station has recently bred 12 strains of Vesta tobacco, which are highly resistant to this disease. In 1950, some 14,000 acres contaminated by this fungus

were grown to Vesta tobacco which produced a crop worth some $7,000,000, where old tobacco varieties could not have produced enough to be profitable.

IMPROVEMENT OF FORAGE CROPS BY BREEDING

Compared with improvement work in cereal crops, the breeding and testing of superior strains and varieties of forage crops is of rather recent origin. Growers in all sections of the country used to depend upon locally grown seed which, in many instances, was from hay that was not harvested or pastured, due to weather or other factors. In recent years, interest in cheaper livestock production, soil improvement, and lower labor costs, has stimulated research that would help farmers expand forage crop production. More and more of the better soils are being devoted to the growing of hay and pasture crops. Much research has been done on fertilization, seeding practices, and forage crop management. Such factors as susceptibility to drought, insects and diseases, poor seed setting, undesirable growth habits, and lack of palatability are being investigated as they may limit the growing of grasses and legumes.

Varying soil and climatic conditions call for forage crops especially adapted to special areas and regions of the United States. State experiment research aims to produce strains and varieties which are suitable for the area in which they are grown. This research is an effort to fit a particular crop or variety to a peculiar environment. Unnecessary duplication is avoided by cooperative breeding programs between stations and the Department. Such cooperative programs are now in progress in the northeastern and northcentral regions. This pooling of breeding research speeds up development of adapted strains and eliminates the great number of strains and varieties having only minor differences.

The breeding of forage crops is a new and very important field of research. Varieties are constantly being created or changed. It is necessary to maintain large stocks of breeding materials, including inferior types, as, frequently, desirable characteristics are found in otherwise poor strains and plant breeders can incorporate these characteristics in more valuable strains.

Hay, Pasture, and Silage Grasses

Until recent years, the breeding and improvement of grasses lagged behind that of legumes. Production was limited to a few species, mostly native grasses, and, in many cases, these were grown only on land which was unsuitable for other crops. Research has shown that livestock can be grown on pasture much cheaper than on dry-lot feeding which requires the addition of large quantities of corn and high-protein cereals. Furthermore, harvesting costs are greatly reduced. More and more good land has been devoted to hay and pasture crops and the demand for superior varieties and species has increased. This is true, not only in the more humid areas, but in the range lands of the West.

Many States are now engaged in the breeding of more profitable grasses, both for grass-legume mixtures and for pure stands.

Intermediate wheatgrass is widely grown throughout the Western States. The Idaho station reports that the variety now in use is a conglomerate of many types and strains. An improved strain of uniform growth habits and appearance, producing increased yields, would greatly increase the value of this grass. Two selections have been made at the Idaho station, a tall-growing type showing promise for grass-legume mixtures for hay and summer pasture, and a dwarf low-growing type for pasture use. The tall-growing type is composed of a mixture of dark-green and bluish-green plants. Efforts are now being made to get a standard color.

Kentucky 31 fescue, originated by the Kentucky station, has made a phenomenal increase. In 1940, only 50 acres were grown in Kentucky and in 1949 over a quarter million acres. Kentucky farmers produced over 4 million pounds of seed in 1949 with a value of at least $2,000,000. This grass will grow well on all but very sandy soils and those in low fertility.

Many scientists have successfully utilized outstanding plants from old fields and stands in forage breeding work. After careful trials, the Massachusetts station reports this method less successful than seed samples from outside foreign and domestic sources. The low level of soil fertility which prevails in nearly all old grass fields appears to be responsible for the poor results obtained in collecting breeding material from native fields.

One of the most important soilage crops grown in Puerto Rico is Merker grass. Numerous crosses and strains of this grass have been produced at the Puerto Rico station and, in 1949, one cross, F_1 208X1, produced 77 tons of green forage per acre. This is an increase of 3 tons over the commonly cultivated Merker and if the new strain should be grown on the 2,000 acres now devoted to common Merker grass, the forage value would be increased at least $30,000.

Tests at the Utah station have shown that crested wheatgrass is more valuable for reseeding intermountain ranges than all other species combined and extensive work is now under way to develop superior strains of this grass. Special emphasis is being given to seed-production studies.

The Washington station is also giving considerable attention to crested wheatgrass and efforts are being made to develop a large-seeded, awnlett-free strain which is resistant to stem smut. A nursery of 6,000 selections was planted in 1949, and the data obtained indicated a correlation between seed size and presence of awnletts. Significant differences were obtained in threshability, seed weight, and number of seeds per plant.

Manchar smooth bromegrass, which was developed jointly by the Idaho station and the Department, is adapted to all of the Pacific Northwest. This variety has produced higher hay and seed yields than other varieties under both dryland conditions and irrigation in Idaho. It is equally well adapted for use in alfalfa-grass mixtures and as a pasture grass.

The Nebraska station has released two new grass varieties, Nebraska 50 intermediate wheatgrass and Nebraska 27 sand lovegrass. The new intermediate wheatgrass is outstanding in uniformity of seed and forage characters. It has a spreading habit of growth and is well adapted for seeding waterways. Further tests are being made to determine its adaptability under different soil and climatic conditions.

Legumes for Forage and Soil Improvement

The high protein content of legumes makes them superior crops, both individually and when grown in hay and pasture mixtures. Their ability to fix nitrogen makes legumes invaluable for soil improvement purposes.

Much breeding and improvement research has been undertaken in connection with such legumes as clovers, alfalfa, and soybeans but superior types and varieties are continually being sought. In the past few years, new legume crops, such as kudzu, crotalaria, trefoils, and hairy indigo, have been introduced and have proved to be invaluable in those areas where the older legumes are not adapted. Breeding work on these latter crops is in its infancy and rapid advancement is expected. At the same time, continual research is being conducted in efforts to produce superior strains and varieties of alfalfa and clovers resistant to disease and adapted to various soil and climatic conditions, for use as hay, pasture, and silage and for soil protection and improvement.

The Alabama station has developed a new selection of vetch, designated as Auburn Woolypod, which is now under test throughout the Southeast. This strain produces more green material earlier in the spring than any other variety tested. Seed of this variety is being increased in Oregon and Texas, as well as in Alabama, and it will be released as soon as sufficient seed stocks are available.

Two selections of Augusta vetch, which consistently volunteer in grass sod, have been isolated by the Florida station. Both strains are productive, one making rapid fall growth and maturing early and the other making somewhat slower growth. These strains are to be tested further in pasture sod.

A test of red clovers at the Indiana station in 1949 showed that Dollard, Ottawa, and an unnamed Purdue strain exhibited marked resistance to northern anthracnose. This resistance was reflected in increased forage yields.

Kenland red clover, which was developed at the Kentucky station, was grown for seed production on about 500 acres in Kentucky in 1949. Larger acreages were grown in the Western States. This variety produces about 25 percent more hay than the best of other adapted varieties and is longer lived. Kenland was given a high place in the National Foundation Seed Project.

Plant breeders at the Louisiana station are breeding legumes for higher seed yields, drought resistance, and increased forage yields. Major emphasis is being given to white clover, red clover,

and annual lespedezas. Polycross combinations of white clover are being tested to determine the combining ability of all of the present outstanding clonal lines. Ten of 15 polycross entries have significantly outyielded Ladino clover in forage production. Their seed production is equal or superior to the parent variety, Louisiana white clover.

In many dry areas, sweetclover is one of the very few legumes which can be grown successfully. Its use is limited by the stemmy, coarse nature of the plant and the toxicity of improperly cured hay. These factors are receiving major emphasis by the Nebraska station. Breeding material is now available which is nearly free of coumarin, and other lines are characterized by their bushy growth habit and fine stems. Crosses are now being made between these two types in an attempt to combine the two characteristics into one desirable strain.

The Georgia station (coop. USDA) has developed a superior strain of winter peas. This new variety, unnamed as yet, is a selection from a cross between the Austrian winter pea and a Puerto Rican green pea. In trials it has produced more green matter than commercial varieties and is 1 to 2 weeks earlier than the Austrian winter pea.

Breeding Methods Extend Alfalfa Production

Formerly, the Midwest and West were regarded as the Nation's alfalfa-land. In recent years, the breeding of adapted varieties of alfalfa, such as Atlantic and Narragansett, has made it possible to grow alfalfa economically in large areas of the East and Middle West and to some extent in the Southern States. This has materially reduced the costs of high protein feeds and has probably altered the economy of the dairy industry more than any other livestock enterprise. Much attention has been given to the breeding of insect- and disease-resistant varieties. At the present time, the major production of alfalfa seed is in the West but efforts are being made to produce strains which will set and mature seed in the more humid regions.

Ranger alfalfa, released by the Nebraska station in 1942, is an excellent wilt-resistant variety and is highly productive. Ten-year results at the Wisconsin station show that Ranger is superior to many, if not most, of the commercial varieties now grown. Stands are longer-lived and it fills an important need in long rotations, in pasture mixtures, silage or hay, and in soil conservation practices.

Alfalfa breeding at the Indiana station is aimed at improving the economy of alfalfa production and increasing the seed yield. Recent studies have shown that genes in alfalfa conditioning reaction to common leaf spot (*Pseudopeziza medicaginis*) exhibit dominance to resistance. This fact will materially simplify the production of synthetic varieties showing resistance with consequent improvement in the quality of hay as a result of less defoliation.

Alfalfa makes an excellent green manure crop and the Ohio station has determined that the best varieties for this purpose

are the least winter-hardy ones. In 1949 tests the nonhardy varieties, such as Indian, African, and Chilean, produced 15 to 100 percent more organic matter between April and November than the best winter-hardy hay varieties.

The Arizona station has released 275 pounds of seed of a superior strain of alfalfa to the Arizona Crop Improvement Association to be distributed to and multiplied by commercial growers. This strain was produced from selections of Indian and African varieties. The Arizona station is also attempting to incorporate wilt resistance into nonhardy susceptible types by making natural crosses between Hairy Peruvian, African, Indian, and Chilean alfalfas and the hardy, wilt-resistant varieties, Ranger and Buffalo.

The California station has produced a strain of alfalfa, California Common 49, which is resistant to the dwarf virus disease. This variety is recommended for areas where dwarfing is the major factor in reducing life of stands. It is believed that it will prolong the life of stands by at least 2 years in areas where the dwarf disease is common.

Considerable interest has been shown in a low-crown, somewhat spreading type of alfalfa because of its possible greater persistance under repeated cutting or grazing. The Iowa station has produced a synthetic strain of this type which, in preliminary tests, rated high in yield performance as compared with more erect strains. It was developed by combining strains for Iowa, Nebraska, and Pennsylvania.

The Kansas station reports that the demand for Buffalo alfalfa seed has been so great during the past few years that, in 1949, there were 2,261 acres of Buffalo certified in Kansas as compared with 60 acres of Kansas Common. This is a complete reversal of the situation of 5 years ago. In preliminary tests a new variety produced by the Kansas station showed a yield 11 percent higher than Buffalo and a wilt resistance 20 percent higher.

At times breeding research is retarded by lack of suitable breeding material and the plant breeder must produce his own. This condition will be minimized in the case of alfalfa breeding by a recent project at the Nebraska station. Genetic stocks and germ plasm material are being preserved and perpetuated for the use of plant breeders in all parts of the country. These stocks represent various flower colors, red-colored roots, white seed, multiple leaflets, varying degrees of reaction to diseases, and decumbent and upright growth habits. A number of foreign introductions are also being grown for observation and breeding purposes.

Bacterial wilt which causes loss of stands was formerly thought to be the principal disease of alfalfa. Research at the New Mexico station resulted in the discovery that fusarial wilt of seedlings and mature plants is of equal or greater economic importance in New Mexico than bacterial wilt. Surveys of breeding stocks show that there are significant differences in the susceptibility of different varieties to fusarial wilt. This indicates the possibility of breeding for resistance to this disease.

Narragansett alfalfa, developed by the Rhode Island station, has been tested by a great number of States and was found to have a wide adaptation. Seed of this new variety is being increased commercially in Idaho and by the Utah station.

Alfalfa variety and strain tests have been conducted by the Utah station since 1938 and more than 100 strains have been evaluated for seed production. High seed production has generally been found to be associated with high forage production. As a result of this work, farmers now have the benefit of wilt-resistant alfalfas which are high in seed and forage production.

FORAGE CROP PRODUCTION

Interest in the production of forage crops and the establishment and maintenance of grazing lands continues to increase and the demands for better crops and improved methods call for more and more forage crops research by the State experiment stations and the Department agencies. Livestock growers are finding that all types of livestock can be produced more economically and efficiently by making greater utilization of pastures and forages. Such extensive use has created problems in management and use of grassland that must be solved in order to get the most out of grasses and legumes.

More Adequate Seed Sources are Needed

One of the chief handicaps in many sections of the country is the lack of seed of the better varieties of forage crops. Forage seed production is beset with many problems and, in many instances, it becomes an unprofitable and uncertain undertaking. Many of these problems are now being investigated by experiment stations throughout the country.

The Kentucky station has found that seed yields and percentage recovery of seed in Kentucky bluegrass are determined largely by the numbers of two destructive insects, *Miris dolabratus* and *Amblytylus nasutus*, and the supply of available nitrogen in the soil. Chlordane rated high in the control of these insects, and it was estimated that the seed yield was doubled when the insect population was reduced. Spring application of nitrogen was more effective than fall application and where insect control was practiced, nitrogen was effective up to the 50-pound (per acre) level. When insects were not controlled, nitrogen was effective up to the 100-pound level. In the case of Kentucky 31 fescue, the seed yield was doubled by the application of 200 pounds per acre of ammonium nitrate. It was estimated that, as a result of these studies, growers of Kentucky bluegrass seed in 1949 increased their profits by $75,000.

A study of bromegrass seed production by the Iowa station revealed that substantial increases were brought about by a single application of insecticide just before the second crop bloomed. Here again nitrogen was the key element, seed yields ranging from 213 pounds per acre on unfertilized plots to 959 pounds per

acre where 240 pounds of ammonium nitrate was used. The Utah station found that dusting with DDT to control lygus bugs increased the yield of alfalfa seed from fourfold to tenfold. The average State yields have increased almost threefold since DDT became available as an agricultural insecticide.

In many instances, success or failure in producing legume seed is dependent upon insect pollination. The Florida station found that red clover supplied with extra honey bees produced 90 pounds of seed per acre as compared to 11 pounds where bees were not supplied. Similarly, studies at the Kansas station gave evidence that a colony of honey bees, consisting of from 10,000 to 11,000 bees, will visit enough alfalfa flowers during a 20-day blooming period to make 120 pounds of seed and at the same time gather enough nectar to store 53 pounds of honey. Furthermore, enough nectar is produced on 1 acre of alfalfa to support 3 colonies of bees. In an extensive study of the role of bees in legume pollination, the Oregon station found that Ladino clover, caged to prevent visitation by bees, produced an average of 444 seeds per 100 heads, whereas uncaged plants produced 15,554 seeds per 100 heads.

A great need exists for improved seed-harvesting equipment. The Michigan station has studied various harvesting methods and determined seed losses. No method now in use is very satisfactory as seed losses during harvesting ranged from 23 to 84 percent, with an average loss of 60 percent. However, by using proper precautions seed yields can be increased even with equipment which is now available. At the Mississippi station a yield of 218 pounds of common white clover seed was obtained, an increase of 75 pounds per acre over normal harvesting methods, by using the following methods: (1) Mow when 75 percent of the heads are dark brown, (2) let crop cure for 1½ days, (3) do not windrow and use a pick-up attachment for the combine, (4) run the cylinder at maximum speed and use a clover screen, and (5) run the mower and combine at slow speed.

Forage Stands Dependent on Methods of Seeding

The life of a forage crop stand depends in large measure on good germination and seedling establishment. Many growers have found that a little extra care at seeding time pays big dividends. However, much remains to be learned about proper seeding methods and management while the young plants are becoming established.

The Florida station has found that wiregrass areas can be seeded successfully without seedbed preparation by burning off the wiregrass in the fall and liming and fertilizing the soil.

Evidence has been developed by the New York (Cornell) station which indicates that the fertility level and the soil moisture content during emergence and early growth are of prime importance and that where seedings are made on hill land that cannot be plowed, reducing the competition from the original sod will aid materially in the establishing of seedlings.

The Vermont station is studying the competitive effect of weeds on forage crops seeded at different times. Weeds make little or no growth during the late fall and winter months and competition is at a minimum. However, most legumes cannot be seeded successfully in the fall. Efforts are now being made to determine the causes of the winter killing of legumes after they have become established. If these causes can be determined and overcome, the establishment of good legume stands will be greatly enhanced.

Seedlings of many legumes cannot make efficient use of drilled fertilizer until they are several weeks old and this often results in poor stands. The Ohio station has developed a unique "band seeding" method for meadow crops which promises to reduce this difficulty. Tubes from the grass seed box on the grain drill are extended to drop the forage crop seed in the furrow behind the disks. Thus, the seed is placed directly over the fertilizer band and the young seedlings can make immediate use of the nutrients. Preliminary tests indicate that rates of seeding by the band method may be only three-fourths to two-thirds of the rates needed for good stands by broadcast seeding methods.

The eccentric disk, developed by the Wyoming station (coop. USDA) has greatly aided successful seeding of range land. The small depressions, or pits, collect moisture and provide more favorable conditions for young grass seedlings. In 1949 it was found that lambs grazed on land seeded in this manner made greater gains and that twice as much perennial grass was left on pitted pastures as on unpitted land.

Increased Production Through Fertilization

The use of better soils and fertilizers has greatly increased forage production in recent years. In the Southern States, for example, the production of hay increased an estimated 72 percent between 1930 and 1945. Although some of this increase has been due to larger acreages, it is recognized that better management practices have been responsible for a large part of the increase in production. A large amount of research is now being done on the nutritive requirements of various forage crops and it is anticipated that even greater production will take place in the future.

Fertilizer tests at the Indiana station indicate that, on permanent grass pastures, phosphorus, potash, and lime give very little increase in production but that with the addition of nitrogen to the treatment, very significant increases occur. On the other hand, grass-legume mixtures showed no response to nitrogen fertilization.

The Colorado station has determined that the application of 100 pounds of ammonium sulfate, at a cost of about $4 per acre, will produce about 1,300 pounds of additional air-dry forage when applied to smooth bromegrass, crested wheatgrass, or intermediate wheatgrass. However, this increase did not occur with native or seeded western wheatgrass. At a rate of 200 pounds

per acre, additional forage was produced but at declining economic returns. Mixed fertilizers were not sufficiently better to warrant the extra expense.

In some areas of Florida, the natural supply of sulfur is low and it has been found that yearly applications of sulfur and soluble forms of phosphorus increase the yields of clover and grasses. Preliminary tests at the Florida station indicate that fertilized grasses maintain a higher nutritive value and yield later in the fall than unfertilized pasture.

The Illinois station, in a study of the effects of soil fertility on the yield and composition of roughages, has concluded that, in general, the composition of forage is determined more by species and stage of growth than by the application of lime and phosphorus. This was especially true of calcium content.

On a Paxton loam soil, the New Hampshire station has demonstrated that the use of potash will help to maintain a stand of clover in hay and pasture forage. When nitrogen is added, however, the percentage of clover drops although the total yield of forage is markedly increased. Thus, when using legumes with a short life span, the grower should consider the use of nitrogen when grasses begin to predominate.

In a controlled greenhouse experiment, the New Hampshire station has produced tentative evidence that new seedings of Ladino clover may benefit from small applications of boron even though no deficiency symptoms seem to be present in the foliage of plants on untreated soil. Additional work with boron on alfalfa by the Virginia station reveals that low yields are not directly associated with a low boron content of the plant. This indicates that yield is influenced by other factors associated with boron. In Virginia most alfalfa fertilizer contains boron and the Virginia study points to the probability that more boron is being applied than is needed.

Many forage crops react differently to the different methods of placing fertilizer and liming materials. The North Carolina station found that an alfalfa-orchard grass mixture is almost twice as productive as a Dallis grass-lespedeza mixture and is correspondingly more demanding in its fertilizer requirements. Placement of phosphorus and potash had little significance but the placement of lime was critical. Mixed placement was best and top dressing gave the least response. This study also showed that grasses are strong competition for the potassium supply in the soil, to the detriment of legumes.

Timing of fertilizer applications is also very important with certain grass species. The Puerto Rico station has demonstrated that nitrogen greatly increases the yield of the most important forage grasses, but it was also learned that the best time of application for yield was not the best time for maximum protein content. Applying all of the fertilizer (200 pounds of ammonium sulfate) immediately after planting both guinea and Merker grasses resulted in a maximum production of green forage and protein. Para-Carib grass gave maximum yields when the nitro-

gen application was split, one-half being applied 6 weeks after cutting and the other half 9 weeks after. All three grasses had a higher nitrogen content, on a dry-matter basis, when the nitrogen application was split in two applications and the grasses were cut at 10-week intervals.

Greater Efficiency Through Proper Management

As long as pastures were confined largely to nontillable land, there was little incentive to improve them by better management practices. In the past few years, the productive capacity of hay and pasture land has increased enormously and much of the research now going on in all sections of the country is aimed at increased production, lengthening the productive life of forage stands, and extending the period of grazing during the year.

In seeking more effective methods of controlling pasture weeds, the Illinois station has found that the application of lime is more effective in curbing weeds and increasing desirable forage than any mowing treatment. It was also determined that two mowings, May 15 and September 15, were just as effective in controlling weeds as three mowings.

Difficulty is frequently encountered in establishing red clover stands following combined wheat. First-year tests at the Maryland station revealed that areas that were mowed within a week after combining, with all straw and plant growth removed, and that were mowed a second time for hay during the latter part of August, yielded 1,830 pounds of red clover hay per acre the following year. Similar plots that were not mowed or that had the straw removed averaged only 963 pounds of hay. Furthermore, clipping and removing the straw greatly aided in controlling insects and diseases. Eight to 10 plants per square foot appeared to be the optimum stand.

The New York (Cornell) station found that species and varieties of grasses or legumes with similar plant form gave growth curves of similar types even though they differed widely in production. Plant composition was markedly affected by advancing maturity and was very slightly affected by the herbage yield as such. Differences in date of maturity are almost as wide between varieties of a single crop as between different grasses or legumes; but seed mixtures of different strains, being more compatible, may be more persistent and valuable than species mixtures. Quick recovery in Ladino clover was largely the result of leaving the prostrate stems as storage organs. No injury to the soil surface resulted from this practice.

In many sections the demand for young alfalfa and the relatively high prices paid for this crop for dehydration purposes have had adverse effects on the vigor and life of stands. The Oklahoma station, in studying this problem, has found that frequent cutting of alfalfa in the bud stage lowers the vigor of the crop and permits weeds to become rapidly established. The root reserves of plants cut in the bud stage were low during the growing season but reserves were high in plants cut at a later

stage of growth. Further study is needed to determine to what extent a stand of alfalfa can safely be utilized for dehydration purposes. Similar results were obtained by the Alabama station.

Mountain meadows of the Western States have been utilized for hay and grazing for many years and many of these areas have become very low in productivity. The Utah station has shown that mountain meadows can be greatly improved by reseeding with improved species. Tall wheatgrass, tall fescue, and meadow fescue have been found to have a high tolerance for the saline condition found in many of these meadows. The yield of meadow hay was trebled by plowing and reseeding and controlling irrigation to avoid prolonged submergence.

The method of utilizing forages, especially pasture forages, is being investigated by many of the stations in an effort to determine the most efficient methods and those which will result in maximum production. The Illinois station has found that alternate grazing gives no increases in yields of pastures and, furthermore, that the clover percentage of alternately grazed fields is usually lower. The Kentucky station also found that alternate grazing of Kentucky bluegrass pastures has no advantage over continuous grazing. The Utah station has found that rotational grazing improves range land and produces greater gains per acre than any other method of grazing at moderate or heavy intensity.

Renovation and Revegetation Increase Pasture Production

Recent research at several stations has shown that many old and unproductive pastures can be economically improved and revegetated without destroying all the existing vegetation. These methods are especially useful for areas that are difficult to plow and work up into a finished seedbed.

Eastern Colorado has thousands of acres of depleted range and abandoned cropland. Recent work by the Colorado station has resulted in large areas of this land being returned to profitable livestock production. In 1949 over 200,000 acres were seeded. Tests have shown that drilling of grasses in spring grain stubble without tillage gives very good results. The Colorado station has also investigated methods for reclaiming and seeding sagebrush land. Burning has proved to be the best method of eliminating sagebrush. Grasses are then drilled in a prepared seedbed at the rate of about 5 pounds per acre. A 6-inch row spacing has given the best results.

Pasture renovation studies at the Maryland station indicate that shallow plowing prior to seeding in order to check existing sods is superior to spring disking. However, disking prior to August seedings has proven very satisfactory.

At the Minnesota station, renovation of old pastures started in late summer gave much better growth of forage by the following July than renovation done in late fall or early spring. Pasture renovation in late fall, or spring, was found to interfere with the nitrogen needed by young plants early in the growing season.

The Vermont station found that in old pastures legumes can be established without killing the grass by rather thorough disking and seeding early in the spring. Grass competition must be reduced by grazing or cutting an early crop of hay. It is estimated that seeding costs and labor can be reduced from one-third to one-half by this method.

Pastures Respond to Irrigation

In the Western States irrigation of improved pastures is standard practice. Limited rainfall makes this necessary. In the more humid areas, the annual rainfall is usually sufficient but distribution is sometimes faulty. During July and August many pastures, especially those of Kentucky bluegrass, become practically dormant because of limited moisture. Several experiment stations are studying the practicability of supplying additional water during periods of low rainfall.

During the 1949 grazing season the Illinois station irrigated a Ladino clover pasture, keeping the soil moisture near the 35-percent level. Although the season was such that irrigation would not ordinarily be thought necessary, three applications of water were made. The increase in pounds of animal gain was 39 percent over the gain recorded for animals on a similar non-irrigated pasture—representing an increase in gross return of $37.50 per acre. Furthermore, in the irrigated pasture there was a higher survival of Ladino clover at the end of the grazing season.

A similar test on a Kentucky bluegrass-white clover pasture was made by the Kentucky station. Distribution of rainfall in 1949 was the best in 20 years and only 2.5 inches of water were applied. However, grazing tests showed that the total digestible nutrients (TDN) produced by the irrigated pasture were 72 percent more than those produced by an unirrigated pasture. Irrigation and application of nitrogen increased the TDN 77 percent.

In the New England States, interest in irrigation has mounted rapidly after three relatively dry seasons. The New Hampshire station has made a detailed study of moisture conditions in pastures and it was determined that, during July and August of 1949, approximately 1 inch of water was used each week. Four irrigations during 1949 produced about 1,800 pounds of dry forage per acre. There was so little growth on a similar non-irrigated field that no harvest could be made.

Good Pastures Prove Their Worth

The value of pastures or forage crops is measured in terms of the livestock or the livestock products that they will produce. Following are a few examples of the effectiveness of improved forages.

The Delaware station found that dairy cows, getting their feed from pasture only, produced only 3 percent less milk than cows on full barn feed. Cows on pasture plus grain produced 17 percent more milk than barn-fed cows.

The value of grass-legume mixtures was shown by a study at the Illinois station. Beef cattle grazed on orchard grass-Ladino clover pasture, producing 4 tons of forage per acre, gained 258 pounds per acre, whereas cattle on a mixture of redtop, timothy, bluegrass, and Ladino clover, producing 6 tons of forage per acre, gained 560 pounds per acre.

Fertilization experiments at the Indiana station showed that nitrogen fertilization on permanent grass pasture under good management will produce as much beef per acre as the more productive legume-grass mixtures.

Studies by the Kentucky station indicate that the total digestible nutrients produced by an acre of Kentucky bluegrass-white clover pasture in the central bluegrass region equals the TDN in 50 bushels of corn and 2.2 tons of alfalfa hay. Although yields of TDN from such pastures varied from year to year, the annual production did not fall below 75 percent of the average, indicating that these pastures are more reliable producers of TDN than most other crops.

Using a ryegrass-crimson clover pasture, the South Carolina station found, in 1949, that grazing cows obtained 60 percent of their required nutrients from the pasture and produced 21 percent more milk than a barn-fed control group. After all costs were deducted, a net profit of $77.73 per acre was realized. In addition, the vitamin A potency of the milk produced by the grazing cows averaged 177 percent higher than that produced by the barn-fed group.

FRUIT AND NUT BREEDING RESEARCH

Fruit breeding research is now largely in the hands of research horticulturists at State and departmental experiment stations. Prior to the development of this cooperative research, the development of new fruits came about largely through selections by enthusiastic fruit growers. That growers were reasonably successful in thus getting new varieties established is shown in the examples of the Concord grape, the Elberta peach, the McIntosh apple. These are still tops among our horticultural varieties. However, with the establishment of organized research, it was quite natural that growers should depend more and more on the technically trained personnel of experiment stations. Discovery of the significance of Mendel's law shortly after the turn of the century awakened great interest in the possibilities of fruit breeding. Other scientific developments, such as use of colchicine in doubling the number of chromosomes, have served to keep active the new interest. Natural mutations such as color sports and large-fruited forms have kept the fruit breeder alert. With the full resources of their experiment station available, our modern-day fruit breeders are annually contributing a most valuable service to commercial fruit growers, farmers, and garden orchardists.

In 1948 the horticultural division of the Minnesota station reported a survey showing that a total of 787 horticultural

varieties had been introduced by experiment stations up to 1947 and that the introduction of another 371 varieties was anticipated in the period 1948 to 1952. Not all of these introductions have established themselves as important horticultural accessions. But a surprisingly large number, especially among the small fruits, such as the grape, raspberry, and strawberry, have been successful. The lower percentage of successful introduction among tree fruits can be accounted for by the greater length of time required to propagate, disseminate, and thoroughly test a more slowly developing fruit such as the apple.

Apples

The Minnesota horticulturists estimate that at least 40 years may be required in the development of a new apple variety. This was clearly shown in the new Monroe apple, introduced by the New York State station in 1950. The parent stock was originated in 1910 from a cross between Jonathan and Rome Beauty.

The Ohio station has introduced the new Melrose and Franklin apples. Melrose was obtained from a cross of Jonathan and Delicious. It is a late-blooming, long-keeping variety of high quality and is adapted to cooking and freezing. Franklin, the variety of McIntosh and Delicious parentage, extends the McIntosh season and equals its parents in color, flavor, and texture. It makes exceptionally good applesauce.

The Monroe apple, which, as previously indicated, is a product of breeding work at the New York State station, has been well accepted by numerous growers in western New York and in the Hudson Valley. Redwell and Oriole apples introduced by the Minnesota station in 1946 and 1949, respectively, provide Minnesota growers with winter hardy, good-quality varieties. Redwell ripens about mid-October and keeps until January, but Oriole matures earlier, ripening 4 to 7 days before Duchess. In addition, Minnesota introduced the Chestnut crabapple in 1946.

In 1942 and 1944 the Idaho station introduced respectively the Idared and Idagold apples, products of an intensive breeding study which had been carried on for several years. Idajon, released in 1949, is a high-quality, deep-red apple, ripening 10 days ahead of Jonathan. The Iowa station produced a series of worthy apples some years ago some of which, including Secor and Sharon, are proving valuable to the growers. Iowa like Minnesota is faced with the problem of winter hardiness. Freezing weather sometimes occurs in late fall before the trees have dropped their foliage and matured their wood.

Illinois has an extensive apple breeding project which is expected to provide eventually some valuable new varieties for the soil and climatic environment of that State. Other States engaged in apple breeding include Arkansas, California, Maine, Michigan, Missouri, New Jersey, New Hampshire, Oklahoma, and Virginia.

Pears

Pear improvement has been handicapped by the exceedingly difficult problem of incorporating in the new varieties resistance to fire blight, the bane of pear producers in all sections of the United States. The Tennessee station rediscovered a promising pear originally developed by the Department and probably a cross between the European pear and an oriental species, and named it Orient. The variety is strongly resistant to fire blight and yields good-quality fruit for canning. Some years ago the New York State station introduced several desirable new Barlett-like pears such as Covert, Gorham, and Ovid. In 1940, Minnesota introduced the Bantam and in 1949 the Golden Spice, both exhibiting winter hardiness and producing good-quality fruits. Other State stations working with pear improvement include California, Illinois, Iowa, Missouri (Mountain Grove), New Hampshire, Oregon, and South Dakota. Oregon has been especially active in the breeding of blight-resistant pear rootstocks, upon which to bud high quality varieties such as Bartlett, Bosc, and Anjou.

Peaches

Improvement of peaches has interested many stations and notable progress has been made in their development.

The Michigan station contributed a number of excellent new peach varieties in the so-called Haven series which includes Halehaven, South Haven, Kalhaven, and Redhaven. A new peach in this series introduced in 1946, was Fairhaven.

The New Jersey station has made important contributions to peach improvement. Since 1945, a total of 18 new varieties has been introduced to the grower. These are Autumn, Cherryred, Constitution, Early East, Envoy, Fallate, Frostgreen, Goodcheer, Honeygem, Jerseyland, Laterose, Maybelle, Newcheer, Redcrest, Rutgers Green Leaf, Rutgers Redleaf, Summerrose, and Wildrose. Rutgers Green Leaf and Rutgers Redleaf are recommended only for rootstocks. The aptly called Prairie series of peaches produced by the Illinois station provides a succession of peaches for that State and includes Prairie Daybreak, Prairie Dawn, Prairie Sunrise, Prairie Rose, Prairie Schooner, Prairie Clipper, and Prairie Rambler. Prairie Dawn is particularly promising because of its high resistance to bacterial spot and unusual hardiness of the flower bud.

California and some Southern States were faced with the failure of so-called northern varieties of peach to leaf out properly in spring. This failure was caused by the lack of adequate low temperatures to break the natural rest period of the peach. By crossing northern varieties with the Peento or Saucer peaches, the California station has developed a number of new peaches which leaf out properly and which have many of the desirable qualities of the northern peaches. White-fleshed varieties in the new group include Babcock, Hermosa, and Rosy; yellow-fleshed varieties include Bonita, Sunglow, Golden State, and Rubidoux.

Other State stations interested in peach breeding include Arkansas, Louisiana, Maryland, Minnesota, Missouri (Mountain Grove), New York State, Oklahoma, Oregon, Texas, Utah, and Washington.

Plums

Plum breeding is more limited than peach breeding. California reports some promising seedlings about ready for naming. Since 1940 Minnesota has named four varieties—Redcoat, Pipestone, Redglow, and South Dakota, the last of which was received as a seedling from the South Dakota station. Several years ago the New York State station introduced several plums including Albion, Hall, and Stanley, the last of which proved a valuable variety not only in New York but in other States. Other State stations interested in plum breeding include Illinois, Iowa, Mississippi, Missouri (Mountain Grove), and South Dakota, which in 1950 introduced the Honey Dew plum a cross between the Gold Plum and the Sandcherry.

Cherries

Cherry breeding like that of the plum is rather closely confined to states in which cherries are grown commercially. California, Idaho, Illinois, Michigan, Minnesota, New York (Geneva), Oregon, South Dakota, and Utah are among the States working with cherries. The Minnesota station introduced in 1949 the Orient cherry a strain of the Chinese bush cherry—described as good for eating and excellent for jellies. In 1946, the Idaho station announced three sweet cherries—Ebony, Lamida, and Spalding. Lamida is more resistant to fruit cracking in unfavorable weather than are the older varieties Lambert, Bing, or Napoleon.

Apricots and nectarines

Various other tree fruits such as the apricot and nectarine are receiving consideration by a few of the stations. South Dakota named a new apricot, Sunshine, hardy in the tree but subject to occasional frost injury because of the early blooming habit of apricots in general. In 1949 the California station introduced the Mabel and Philp nectarines and in 1947 the New Jersey station announced four new nectarines, namely, Nectacrest, Nectaheart, Nectalate, and Nectarose.

Grapes

Grape improvement constitutes an important segment of the fruit breeding activities of the State stations. The extent of the work is shown in the California station report that some 60,000 seeds from crosses were sown in flats in the fall of 1949. Two of California's objectives are to breed grapes resistant to Pierce's disease, a destructive virus, and to powdery mildew, now controlled at high cost with sulfur dust. Since 1946, Cali-

fornia has introduced five new grapes Scarlet, Perlette, Delight, Ruby Cabernet, and Emerald Riesling. Some selections of the Concord type with unusually large berries are under trial.

The Geneva station in New York continues very active in the development of new varieties that combine the hardiness of the native grape with the superior quality of the European or vinifera type. Over the years a number of valuable new varieties have been introduced. Some recently named include Interlaken Seedless, Schuyler, and Steuben, all introduced in 1947. Here again thousands of hybrid seedlings are grown each year in an attempt to improve the grape.

Further south, in North Carolina and Georgia, there is great interest in the improvement of another type of native grape, the muscadine. Normally this species consists of male- and female-flowered vines. Recently the North Carolina station (coop. USDA) has found vines bearing complete or perfect flowers capable of setting fruit without cross pollination. New muscadine grapes introduced by North Carolina in 1946 include Burgaw, Cape Fear, Creswell, Duplin, Kilgore, Morrison, New River, Onslow, Orton, Pender, Stanford, Tarheel, Topsail, Wallace, and Willard.

For the north, the Minnesota station introduced four new grapes in 1944, Red Amber, Moonbeam, Blue Jay, and Bluebell. All are hardy and should benefit growers in a region where the usual varieties are lacking in resistance to low winter temperatures.

Raspberries and blackberries

Bramble fruits, namely raspberries and blackberries, owe much of their present popularity to station and Department fruit breeders. The Latham red raspberry introduced in 1920 by the Minnesota station continues to be one of the leading commercial varieties. The New York State station has contributed over the years a number of excellent red, black, and purple raspberries including the red Newburgh, Taylor, Milton, and September; the black-fruited Bristol and Dundee; and the purple-fruited Sodus and Marion. The Tennessee station has been unusually successful in developing red raspberries that combine the good qualities of the usual horticultural varieties with the disease resistance of Asiatic species. The latest of these is Tennessee Prolific announced in 1948. The New Hampshire station has recently introduced the Durham raspberry, a desirable everbearing variety well adapted to that area.

The Washington station has made a notable contribution to raspberry production in developing a number of new red varieties. One of these, the Washington, has rapidly become the leading variety in the important producing area of western Washington. Raspberry breeding has been actively pursued at the North Carolina station (coop. USDA). Here as at Tennessee, a serious effort has been made to combine the high quality of the usual horticultural varieties with resistance to leaf-defoliating

diseases, using Asiatic species as a source of resistance. Many promising seedlings have been developed, a few have been introduced, and others are about to be named.

Blackberry breeding has received the attention of the Oregon station (coop. USDA). In the relatively mild climate of western Oregon such types as the Himalaya and Boysen thrive and provide crossing material. Olallie, a seedling of Black Logan × Young, and Chehalem, a cross of Himalaya × Ideal, are recent introductions of promise. Three blackberries, Big-Ness, Earli-Ness, and Regal-Ness, released by the Texas station in 1946 offer much promise to Texas producers.

Strawberries

With the appearance of relatively new diseases such as red stele and various virus troubles, great interest has been shown in the improvement of the strawberry. Temple, a recent introduction by the Maryland station (coop. USDA), has notable resistance to red stele. Redcrop, introduced by the New Jersey station in 1949, also possesses resistance to red stele and is very good for freezing. Vermilion, a 1950 production by the Illinois station, is a high-quality berry with marked resistance to red stele and certain leaf troubles. The everbearing Evermore, and the spring-bearing Arrowhead, recent introductions by the Minnesota station, are productive hardy varieties of value to northern growers. Great Bay introduced by the New Hampshire station is a promising large-fruited, late variety for that area.

Lassen, Sierra, Tahoe, Shasta, Donner, Campbell, and Cupertino bred by the California station provide new varieties for various locations in the State, where virus diseases and other troubles beset the older varieties. The Tennessee station with its comparatively new varieties Tennessee Beauty, Tennessee Supreme, and Tennessee Shipper, provided growers with a series of fine-quality disease-resistant varieties.

Many other State stations are active in strawberry breeding. Over the years the New York State station has distributed several fine varieties including Catskill which has become an important commercial variety in the Northeast. The North Carolina station (coop. USDA) has been successful in breeding new strawberries. One, Massey, has proved to be unusually productive in North Carolina and has been widely accepted by growers. The Louisiana station by rigorous selection methods has developed a number of new strawberries more resistant to leaf diseases than older varieties such as Klondike. Klonmore is one of the best of Louisiana productions with 80 percent or more of the State acreage now planted to this variety. Later introductions include Konvoy, a fine home-garden and processing berry, and Marion Bell, a promising shipping variety of unusually bright attractive color.

The Washington station has recently named a promising new strawberry seedling Northwest that possesses resistance to yellows.

Blueberries

No fruit has been developed from a wild fruit to a cultivated crop as rapidly as the blueberry. In 1949 the New Jersey station (coop. USDA) introduced two new varieties, Berkeley and Coville, both with unusually large berries of good eating and market quality. North Carolina (coop. USDA) introduced two blueberries in 1949, named Wolcott and Murphy. The Washington station is breeding blueberries adapted to the Pacific Northwest. Some of the more northern stations such as New Hampshire, Maine, and Michigan are interested in the selection of better types of low-bush blueberries. In the far South, certain of the stations are interested in improving the so-called rabbiteye blueberry, long esteemed but generally neglected by horticulturists.

Miscellaneous small fruits

A joint project of the New Jersey and Massachusetts stations (coop. USDA) yielded three new cranberry varieties in 1950, namely Beckwith, Stevens, and Wilcox. Beckwith and Wilcox possess resistance to the leaf hopper which transmits the serious false blossom virus from diseased to healthy plants.

Of peculiar interest, is the beginning of improvement from the wild to a cultivated state of the beach plum which has been valued since early colonial days as a source of jelly and preserves. The New Jersey station has named a selection from a wild fruit, Raribank. The shrub is described as large as a medium-sized peach tree.

Nuts

In the past, development through breeding of new varieties of nuts has not received the attention it merits. However, the California station has announced a new almond, Jordanolo, which in 1948 was planted to the extent of some 2,190 acres. The nuts are of high quality and have largely replaced the imported Jordan almonds in candy manufacture. Other promising almonds are in the developmental stage.

ORCHARD AND BERRY CULTURAL AND STORAGE PRACTICES

Progress in the fruit-breeding programs of the experiment stations has been matched by similar progress in new knowledge dealing with fruit production. Although one of man's oldest undertakings is the care of fruit trees and of the vineyard, great changes have been made since organized experimental research has been pursued at the experiment stations.

Mulching

Mulching of fruit trees with hay or straw at the rate of 200 pounds per tree annually increased greatly the yield of McIntosh and Northern Spy trees according to observations by the Maine

station. Explanations of the beneficial effect of mulches were forthcoming from the Missouri station where records showed that there was from 2 to 10 percent more moisture in the 12- to 18-inch soil layer under hay or straw mulch than in sodded soil in adjacent plots. The larger differences occurred during relatively dry periods. The soil under mulch was cooler in summer and warmer in winter. In its study of nutrients the Missouri station found that there was three times as much nitrate nitrogen in the top 6 inches of soil under hay and twice as much under straw as under sod alone. There was somewhat more available phosphorus and potassium in the upper soil layer beneath the mulch than under sod. There was less calcium in the upper 6-inch soil layer under mulch but at a depth of 12 to 18 inches there was more calcium under the mulched than under the unmulched areas. An additional benefit from mulching with hay was reported by the New Hampshire station which found that all but one of the trees under mulch were free from leaf scorch, the presence of which indicates a lack of available magnesium. Even with applications of magnesium sulfate, leaf scorch was not alleviated in every case. Potassium was found to be more abundant under the mulch. As measured by cumulative yields and gains in trunk circumference hay mulch was distinctly beneficial.

At the Rhode Island station the mulching of blueberries with sawdust improved both yield and growth, as indicated in top and root development. Temperature fluctuations were much less beneath mulch than in the open—they were lower in the summer and higher in the winter. Soil moisture was also more constant under the sawdust cover.

Pruning

The need of adapting the type of pruning to existing conditions was demonstrated by the Utah station in a peach orchard near Ogden. Young trees planted in 1945 and pruned according to four systems which differed in amount of wood removed, yielded in 1949 from 61 bushels per acre for severe pruning to 247 bushels for very light "long" method pruning. The conventional method used by most growers gave 160 bushels per acre.

Comparing four degrees of pruning on Concord and Delaware grapes the Mississippi station obtained the largest yields on the most lightly pruned vines but unfortunately a considerable percentage of the berries borne on vines thus pruned failed to attain full maturity. Reducing clusters to one per shoot increased the percentage of grapes that ripened satisfactorily and also hastened ripening; hence, a combination of light pruning and cluster thinning is suggested as a definitely promising method.

Balanced pruning of grapes, that is, regulating the number of buds left on the vines after pruning to the weight of wood removed, was found by the New York State station to result in increasing yields. In one commercial vineyard pruning Concord grapes according to the balanced system and changing the type

of trellis to obtain better exposure of the vine to sunlight resulted in a gain of 2.7 pounds of grapes per vine. General use of the new method of training and pruning would obviously greatly increase production of grapes per acre in the famous Chautauqua grape country.

Methods of pruning the young fruit tree for the purpose of obtaining a number of sturdy well-placed scaffold limbs have long interested the fruit grower. The Idaho station reports that cutting back the young apple tree at planting time forces new growth from among which permanent scaffold limbs can be selected. As a result much lighter pruning is required later to develop strong symmetrical trees.

Controlling Yields With Sprays

As reported by the California station the addition of a small amount of 2,4–D to oil sprays for citrus fruit was found to oversome certain undesirable effects of the oil such as excessive leaf and fruit drop. In some orchards, the use of the 2,4–D increased gross returns per acre by as much as $100. The use of a water spray of 2,4–D on nearly mature citrus decreased drop and extended the profitable harvest season of oranges, lemons, and grapefruit. Size of fruits was increased without any detriment to fruit quality.

The use of dilute caustic sprays such as Elgetol and Krenite (sodium-dinitro-ortho-cresylate) was found by the Minnesota station to thin the blossoms of the apple effectively if used at the proper stage of flower development and in proper concentrations. Care had to be taken in using this method not to have too high a concentration, since higher concentrations destroyed the blossoms. Some slight injury was caused to the young foliage when the diulte sprays were used, but the trees soon recovered. With the Haralson apple in 1949, a gain of $8.36 per tree in market value of fruit was obtained at a cost for spray of 10 cents per tree. In comparison the gain in market value of the fruit of the hand-thinned trees was $3.45 at a cost of 75 cents per tree.

Material savings to citrus growers and a definite reduction in the potential injury to trees could result from the more careful selection of spray oils, according to investigations conducted by the California station. The results indicated the possibility of cutting the oil dosage in orchard sprays to at least one-half of that now used for conventional spray oils. The efficiency of the heaviest paraffinic fractions was, by the additional of kerosene, increased to equal that of the middle fractions. There was an evident relationship in the efficiency of spray oils to molecular size or weight of oil.

Effects of Storage Atmosphere on Apples

In continuing studies on the effect of modified atmosphere on the keeping of stored fruits, the New York (Cornell) station found that certain varieties of apples and all varieties of peaches reacted unfavorably to controlled atmosphere storage. Applica-

tion of this important information can prevent much loss of fruit during storage. On the positive side, work with the McIntosh apple continued to give outstanding results. This apple, said to constitute 60 percent of New York State's apple production, kept considerably beyond its normal storage period when held at 40° F. in an atmosphere of 5 percent carbon dioxide and 3 percent oxygen. The storage life of the Bartlett pear was prolonged from 2 to 4 or 5 months in modified air storage. The station reports that 15 commercially controlled atmosphere storage rooms have been constructed as a result of this study. The net gain per box of apples ranged from 50 cents to $2.

As established by the Ohio station the respiration rate of fruits such as the apple and peach stored in small chambers is a good index to their potential storage life. Since respiration rate was affected by blemishes of all kinds as well as by physiological age, the results gave a good pitcure of the condition of the fruits. There is a definite practical aspect in the measurement of quality and potential acceptability and value to the consumer.

VEGETABLE AND ORNAMENTAL PLANTS

The vegetable industry, as organized in the United States today, depends on the scientific contributions of plant breeders and horticulturists at the State experiment stations and in the Department of Agriculture for its share in the development of new and better varieties for the American public. Closely related, also, is the research in developing improved kinds of ornamental plants that have an aesthetic value, provide a livelihood for thousands of people, and play an important cultural and psychological role in the American pattern of living.

The plant breeders and horticulturists are well aware of their responsibility, not only in providing horticultural novelties to sustain interest or develop new items for market but also to create varieties that meet the demands of the vegetable and ornamental plant industries for quality, marketing excellence, pest resistance, and handling, storage, processing, and merchandising characteristics. Superimposed on all of these requirements is the present-day demand for nutritional qualities in vegetable crops grown for human food. These are receiving increased attention as our knowledge of the importance of minerals and vitamins to human well-being is expanded. The investigations of the plant breeders and horticulturists are, therefore, greatly diversified. The nature of their research is such that close cooperation with the soil scientist, the entomologist and pathologist, the economist, and the human nutritionist is important.

By utilizing the new findings and techniques of genetics, often requiring years of work in both field and greenhouse, promising material may be disclosed. At this point variety trials are made, usually in coordination with other State and Federal agencies; and if new plants continue to show promise, then large seed stocks

have to be produced to make them available for all those interested in them. Finally the new variety is established in the trade; but the work of the originator does not end here. Further research is necessary to maintain the purity of the strain. Variability remains a factor that may deteriorate a stock, and selecting and culling must continue to perpetuate the merit of the variety as originally introduced.

Vegetable Breeding

Within the past decade there are few agricultural crops that have experienced the revolutionary changes that have occurred with vegetables, particularly with respect to handling, storing, and general merchandising. It is now well established that well-grown vegetables, carefully marketed, and intelligently prepared for eating, can be a vital factor in the physical well-being of the people.

Scientists dealing with all phases of vegetable research are striving to place a superior product on the table of the consumer. The physiologist is working with improved cultural and fertilizer practices as well as better methods of harvesting, transporting, storing, and processing, including canning and freezing. The economist is searching for the means of efficiently placing the produce in the hands of the maximum number of consumers. Finally, the nutritionist seeks foods that will build and maintain strong bodies to better the health of the nation. However, the plant breeder carries the responsibility of creating better varieties to fill all these needs.

How successful a new vegetable variety or strain will be, or how long it will remain a leader, only time will tell. Introductions are announced yearly, and the better kind may follow at the heels of the gold-medal winner of today. Improved handling or grading techniques, mechanical harvesting, and modified canning or freezing methods may send the breeder again on the search for characters that may combine to keep pace with the forward-moving know-how of modern agricultural methods. Also to be considered are the plant pests, both insect and disease, that may destroy the value of either a new or an old variety.

Asparagus

As of the summer of 1950, a survey of some of the recently announced vegetables that have been developed by the State experiment stations will serve to demonstrate the research of the plant breeder. At the Minnesota station a new four-way asparagus has been bred. Trials are now under way to determine the value of this variety at the New York (Cornell) and other stations. The fact that the four parents represented in this new variety are all high-yielding kinds augurs well for the success of the progeny.

While this research has gone on in Minnesota, the California station announced two new strains of the Martha Washington asparagus, Nos. 499 and 500, developed in cooperation with the

Canners League of California. Because of the importance of the asparagus canning industry in California, the canning merits of these two new strains are being tested. They are both relatively free from the enlarged nodes that are not desirable in the colossal sizes used for canning. Although these two strains are still considered to be on trial, some 10,000 acres of the 70,000 acres planted to asparagus in California last year were planted with these two introductions. The California station estimates that it takes 8 years to test thoroughly the progeny of an asparagus hybrid. Since Nos. 499 and 500 were first released in 1944, no final decision can be reached and the breeder will know whether his efforts to grow these varieties are successful, before 1952. At this time No. 500 has taken the lead, and practically all new plantings are of that strain.

Snap beans

Cooperation between the Department's Vegetable Breeding Laboratory at Charleston, S. C., and the State stations, particularly those in Florida and Mississippi, has resulted in the release of a new green-podded bush snap bean called Contender. Parent material includes Commodore, Streamliner, and U. S. No. 5 Refugee. This variety is resistant to common bean mosaic, to "greasy pod," and in a degree to powdery mildew. Successful trials in New York, Michigan, and the South indicate wide adaptability for this variety.

The New Hampshire station has devoted some of its vegetable breeding activity to new bean varieties. Brilliant Horticultural and Flash Horticultural have recently been introduced as varieties of probable merit under the growing conditions in the Northeastern States. The Vermont station reports the use of these new varieties in that State. Tiny Green snap bean has also been introduced by the New Hampshire station within the past 2 years.

The South Carolina station has made its contribution to the presently popular varieties of snap beans. The variety, Cherokee Wax, a counterpart of Black Valentine, seems destined to continue its popularity in the trade, particularly in the Southern States.

Lima beans

New lima beans have recently been developed by several experiment stations. In the 1949 trials, which are part of the National Lima Bean Testing and Breeding Program, a cooperative though informal undertaking to which seedmen, commercial processors, State experiment stations, and the Department contribute, promising selections from the Oklahoma station were revealed. On the basis of present ratings, the early introduction of one or more of these Oklahoma varieties can be expected. The New Hampshire station has recently introduced two varieties of limas, namely, White Mountain Bush and Cowey Red. Satisfactory results with White Mountain Bush have already been reported from practical trials in Vermont.

Pole beans

The Hawaii station has announced a new rust-resistant pole green bean, named Hawaiian Wonder. It provides a new flat-podded pole green bean to take the place of Lualualei, which lost popularity with the devastating rust that occurred in the winter of 1937–38. Hawaiian Wonder was developed from a cross made in 1942 between Bountiful and Lualualei. From the former came the resistance to rust, and 12 subsequent generations of selections finally produced the new variety that is particularly recommended for high elevations in winter and for year-round planting in all areas where rust is likely to be severe at any time.

While the Hawaii station was solving a problem prevalent under the varied climates found at different altitudes in the Hawaiian Islands, the station in Louisiana was developing two pole bean varieties suitable for climatic conditions in the Deep South. Characters particularly suited for canning and freezing were needed. By crossing Ideal Market with Giant Stringless Greenpod, the variety, Canfreezer, was developed and, in turn, a cross between Canfreezer and Savage resulted in the release of Green Savage. Some 10,000 pounds of seed of each of these two new varieties were available in 1950. The Georgia station reports favorably on Canfreezer and Green Savage in its trials.

Cabbage

In its search for improved cabbage varieties that would have fall and winter cold resistance, also resistance to such diseases as mildew and black rot, the Louisiana station introduced the Louisiana Allyear cabbage. As a fall crop its yield proved equal or better than established varieties under test, and its resistance to weather damage and disease was noteworthy.

Carrots

For some years the Idaho station has sought to develop in carrots characters that would contribute to the modern requirements for marketing, particularly in respect to attractive appearance and ease of packaging and icing in transit. Early in 1950 the station announced a carrot variety with the desired qualities. The new carrot was named Imperida. The original selections for Imperida were made in 1940 at Donnely, Idaho, and are believed to have resulted from a chance crossing of Imperator and Red Cored Chantenay. Individual roots of outstanding size and length and tops which were 6 to 8 inches shorter than the field average were found among the segregants. By further selection and inbreeding, this short-top character has been fixed, along with certain modifications in root-size, color, and core.

Although Imperida was developed primarily for use in commercial growing and for its shipping qualities, it also shows promise for home gardens. For commercial use, Imperida's short tops will tend to eliminate the trouble from "excess top" which sometimes is a problem in merchandising the older variety, Im-

perator. Heavy icing to keep the tops attractive for ultimate display will be avoided as will the removal of tops in shipping.

While the introduction of new carrot varieties goes forward, more fundamental research in breeding is being conducted. The California Experiment Station at Davis is studying male sterility in carrots. Just as male sterility is utilized in the breeding of corn, onion, and sorghum, it may be possible to employ this character in the production of hybrid seed in the carrot. This research is important to pave the way for the utilization of the most efficient and modern techniques developed by the geneticist.

Collards

Vates is the name of a new collard announced by the Virginia station. It was developed at the Truck Experiment Station at Norfolk. This plant is low-growing, broad and spreading, and no true heads are formed as in the cabbage. Vates will overwinter in Virginia with practically no injury.

Sweet corn

The close association of sweet corn breeding with that of field corn breeding has given further impetus to new kinds of sweet corn for the table. The Iowa station, long recognized as one of the leaders in sweet corn breeding, has announced the introduction of Iochief as a promising new main crop variety. It is a midseason golden sort of about the same height and maturity as Golden Cross. It shows very few suckers, is a heavy yielder, and appears resistant to wind damage, heat, and drought. It has a relatively long shank that may serve well in connection with machine harvesting.

Also from the Iowa station we now have Iogold, 5 to 7 days earlier than Ioana, Golden Cross, and Iochief, with a yield equal to them but with slightly lower cutting percentage.

The North Dakota station tested some of the newer hybrids developed by the Connecticut Agricultural Experiment Station at New Haven. On the basis of these tests, the North Dakota station recommends generally for trial in the favorable corn areas in North Dakota the Washington, Pershing, and Brookhaven varieties. The first named, although early, is said to combine earliness with high yield, good ear size, and good quality. Pershing and Brookhaven are late varieties recommended for the more favorable corn-growing areas of North Dakota. Figuring in the development of both Pershing and Brookhaven is the inbred, Oh55, made avaiable from the Ohio station at Columbus.

The Connecticut station at New Haven also has recently announced the variety, Grant, a new hybrid, primarily a market garden corn. It has large yellow ears, about 8 to 9 inches long, which weigh nearly 1 pound, unhusked. The quality compares favorably with Carmelcross and Lee and, therefore, can also be grown in the home garden.

The Massachusetts station has introduced two sweet corn varieties, Gold Mine and Golden Jewel, which have received recognition

by workers at the New York (Cornell) station. Gold Mine is reported to be very early. Although somewhat frail, it is of a quality better than most early varieties. Golden Jewel is said to mature slightly in advance of Marcross and to have a quality equal to or better than Carmelcross.

The Wisconsin station in an endeavor to spread the canning of high-quality sweet corn over a longer season in its State and thus add to canning plant efficiency, has announced a new sweet corn, Wisconsin Golden 804. It is a medium-early hybrid for canning industries, truck gardeners, and the home garden. This new variety matures generally about 5 to 7 days ahead of Golden Cross Bantam but with a lighter yield. It has a long, slender 10-row to 12-row ear of excellent quality. In its development a strain was included that originated at the Connecticut Agricultural Experiment Station at New Haven.

A new sweet corn hybrid, Penndale, was made available to growers at the Pennsylvania station. This variety was first recognized in 1944 as having superior quality. It is a first-generation cross of two inbred lines, one parent being P39 from the Indiana station and the other a Pennsylvania strain, S3–61. The hybrid was bred for high quality, desirable flavor, and tenderness. It is a yellow corn suitable as a market or a home-garden type and especially suited to frozen storage.

The following varieties recently developed by the Maine station are available for growing under the special requirements for the successful production in that State of sweet corn for both garden and canning uses. For canning, Early Topcross, Dirigo, Maine, and Tricross; and for the home garden, Northland and Early Golden.

Cucumbers

In 1948 the Mississippi station released Magnolia, a new cucumber variety for pickling. Magnolia resulted from several generations of inbreeding and selection in the progeny of a cross between the commercial pickle variety, National Pickling, and an unnamed hybrid selection received through the Department from the Puerto Rico station.

Palmetto, a variety from the South Carolina station, continues to gain in popularity since its introduction several years ago. Its high resistance to downy mildew makes this new variety particularly valuable for fall production in southern areas. Now from the South Carolina station's Truck Experiment station at Charleston comes the announcement of Santee. Tested in the Southern Cooperative Trials with which a number of State stations are associated, the Santee was the outstanding cucumber variety in the 1949 trials. In these trials Santee was judged to have the same fruit size, length, and general shape as Cubit but, in general, matured slightly earlier. Whereas Cubit is extremely susceptible to both downy mildew and angular leaf spot, Santee carries moderate resistance to both. In addition, Santee is reported to slightly excell Cubit in fruit color and shape as well

as vine vigor. The South Carolina station expects seed of this variety to be available to growers in 1951.

The Ohio station announced a new cucumber variety to be called Ohio MR17. The parent strain, a cross between Chinese Long and Early Russian, was obtained from the New York (Cornell) station and is the result of several backcrosses with National Pickling. Intervening selections for resistance to mosaic, as well as for shape, color, and texture, were made between each backcross. The variety should be available for rather general distribution in the spring of 1951.

Yorkstate Pickling is the name of a new mosaic-resistant cucumber from the New York (Cornell) station. It was bred from National Pickling, Chinese Long, and Early Russian. Designed for use as a small pickle, it has a healthy, vigorous vine, is prolific, and the fruits are of the National type with black spines, blunt ends, good uniformity, and a medium-dark color. Looking forward to 1951, plant breeders at Cornell plan to introduce Niagara, and seed stocks of this variety are being developed to this end. Niagara is reported to be a slicing type with outstanding fruit color and a shape much like Cubit. It has high resistance to mosaic, and its use in areas where mosaic is a problem is recommended.

The Maine station, working particularly on the problem of scab on cucumber, has developed a variety named Highmoor. This cucumber is recommended in the Northern States, particularly where scab has been troublesome.

Eggplant

Eggplants produced in Florida in 1948 had a value of over 1½ million dollars. The fungus disease, Phomopsis, however, which causes tip-over, leaf blight, and fruit rot, has created a serious hazard to this profitable industry. Plant breeders at the Florida station tried to counteract this serious situation and within the past year announced two Phomopsis-resistant varieties. Florida Market and Florida Beauty are the names given to these two new eggplants. The former is a winter and spring yielder, maturing in about 83 days; whereas the latter is suited for fall and early spring production and matures in 80 days. One 10-acre commercial field of Florida Market has produced a satisfactory crop in central Florida in 1949, although neighboring fields suffered from 50 to 100 percent losses from Phomopsis blight.

Lettuce

With the increased emphasis placed upon the use of salads to supplement our intake of minerals and vitamins, lettuce as a base for vegetable and fruit salads has gained increasing popularity. At the Pennsylvania station, breeding for improved head lettuce has been under way since 1925. In 1949 the station's test plots comprised approximately three-fourths of an acre and contained 25 varieties and more than 100 breeding lines, a total

of 15,000 plants. Out of this breeding research have come the head lettuce varieties, Premier Great Lakes and Pennlake. Both produce heat-resistant, good quality, solid heads and have quickly been taken up by the trade. Approximately 2,000 pounds of Pennlake seed were distributed in 1949, and over 5 tons of Premier Great Lakes were available.

The New Jersey station has been cooperating with the Department since 1948 in its endeavor to develop superior varieties of lettuce. From this cooperation involving test plots in seven counties in New Jersey, has come the variety, Progress. It is an early, dark-green, thick-leafed, heavily savoyed, crisp lettuce, a production of selection from a cross between Imperial 44 and an unnamed hybrid seedling.

Muskmelons

Muskmelons continue their popularity, and the demand for improved varieties is recognized at several of the State stations. Granite State was released by the New Hampshire station several years ago, and it has gained steadily in popularity as trials have been conducted in various parts of the United States. It was reported to have been judged excellent in the 1950 All America Vegetable Trials. Much interest is centered on the variety, Minnesota Midget, originated at the Minnesota station. It is small-fruited and wilt-resistant, and in addition, it is of good quality, matures early, and is productive. Also from the Minnesota station, New Far North has been announced as an inbred and selected variety from the original, with improved uniformity and quality.

Okra

Superior varieties of okra have been developed by several State experiment stations. Clemson Spineless was originated at the South Carolina station, and Louisiana Green Velvet, Louisiana Velvet, and French Market were produced at the Louisiana station.

Onions

In the past year favorable reports have been received including those from the vegetable trials at the North Dakota station on the new onion variety, Iowa Yellow Globe 44, developed at the Iowa station. The new onion is reported to have superior keeping qualities, attractive color, and remarkable uniformity at date of maturity. It has a deep globe and tough outer scales that adhere to the bulb to give it a prolonged storage life.

Typical of the excellent cooperative work between the Department and the State stations is the joint announcement of a new onion variety, Excel (Bermuda 986). This variety resulted from coordinated research by workers in the Department with the California and Texas stations. Excel produces 35 percent more onions of high quality, 10 to 14 days earlier than the conventional Yellow Bermuda, and has fewer bolters, doubles, and splits, off colors, and other undesirables.

Peas

Mayflower is the name given to a new garden pea, introduced recently by the New Hampshire station. It has performed well under environmental conditions found in the more Northern States. In an effort to improve on the Creole variety, Louisiana station workers have introduced the Louisiana Bayou. In many respects it resembles the Creole, but the pods and peas are a darker green.

Pepper

State experiment stations have originated new pepper varieties that give promise of long life as commercial varieties. Pennwonder from the Pennsylvania station continues to hold its place as a recommended variety, against other popular varieties, such as Merrimack Wonder, which came from plant breeders at the New Hampshire station.

In the South, where the "hot" or pungent varieties are in greater demand, the Louisiana station has introduced the following peppers—Baton Rouge Cayenne, Lafayette Sport, and Iberia Tabasco. These three varieties are reported to be the leading kinds grown in Louisiana. Dixie Wonder, a cross between California Wonder and commercial types, was also introduced by the Louisiana station. Just released from the Southwest is a chili strain from the New Mexico station. New Mexico Strain No. 6 was released from 49 progenies. Tests to date indicate that this new variety is potentially capable of increasing the yields of marketable chili by at least 10 to 25 percent over varieties now grown.

Spinach

Virginia growers have long sought improved varieties of spinach, particularly strain resistant to blight, which can cause havoc in the truck-growing areas of eastern Virginia. The Virginia Truck Experiment Station has announced a new variety called Domino that can be successfully planted in that area from late September to early March. It is a cross between Old Dominion and Nobel. The plants are large and flat growing. Because this new variety grows rapidly but will bolt early, it is particularly adapted to fall planting.

Squash

The [Connecticut] Storrs station has developed new squash varieties. Caserta is an early type of Cocozelle squash that is remarkably prolific. Reports have been received of a production of 30 fruits per plant. The Uconn is another variety from plant breeders at the Storrs station. This variety, which quickly followed Caserta to national recognition, is of the Acorn, or Table Queen, type, growing on a bush that occupies a space about 3 by 3 feet. The fruits can be eaten during the summer or, because they keep well, they can be stored for use during the winter.

The Uconn was developed by crossing the vining-type Acorn with the summer bush Early Prolific Straightneck.

The New Hampshire station has developed a new winter squash named Bush Buttercup that yields a small fruit of high quality. It has a rather flattened shape with a circular "button" on the blossom end. The flesh is thick and of high quality without stringiness. It has been found to be an excellent squash for freezing. Baby Blue is another variety developed at the New Hampshire station. It also produces more of a bush-type plant than most of the winter squashes. The fruit could be considered a diminutive Blue Hubbard.

The Minnesota station's latest squash contribution is Rainbow. It is one of the so-called family-sized squashes of the banana type. The fruits weigh 3 to 4 pounds and will mature in from 65 to 120 days, depending on location. Its flesh is 1 to 1¼ inches thick, edible to the thin shell, and is of fine texture and moderately dry. California growers are looking forward with interest to the results from trials of a new squash variety named Orange Banana that has just been released from the California station.

Tomatoes

The tomato is considered our most important fresh vegetable. Because it is vulnerable to a number of devastating diseases and because of the importance of the crop, a continuous challenge faces plant breeders working with tomatoes. Their aim is to develop new varieties with greater resistance to disease and better quality.

For the past several years the tomato has given a higher total cash income to Hawaii's farmers than any other vegetable crop. Tomato breeding research is, therefore, important in Hawaii. Within the year the Hawaii station has announced seven new tomato varieties. These are reported to be resistant to three destructive diseases—spotted wilt, fusarium wilt, and gray leaf spot. They have been named Hawaii, Kauai, Lanai, Oahu, Maui, Molokai, and Niihau. In the complex parentage of these new varieties are combinations that have been developed in the Department and at the New Hampshire, Missouri, and California stations. Also included in the parentage is the spotted wilt-resistant variety, Pearl Harbor, introduced earlier by the Hawaii station.

Three new tomato varieties introduced by the New York State station have recently been under the critical eye of commercial production. Gem, Red Jacket, and Longred are the names of the new arrivals. They accounted for more than half of the acreage grown for sale to New York canneries in 1949. Gem is noted for its heavy yield when it is close-planted on fertile soil. Red Jacket is popular because of its striking color for juice, catsup, and chili. Longred is prized for its good red color and the length of its season.

The New Hampshire station has introduced the Orange King, New Hampshire Victor, Orange Chatham, Window Box, Tiny

Tim, Dixville, and High C varieties. Dixville is reported to be a productive, very early-maturing variety. High C is noteworthy because its fruits, when tested, were found to contain more than twice the vitamin C content found in most tomatoes.

From the Pennsylvania station comes the Keystate Hybrid tomato, reported in Pennsylvania to have out-yielded the New Jersey stations famous Rutgers variety by 20 to 25 percent. Its future will be watched with much interest.

The Wisconsin station developed an early variety, with great tolerance to early blight, particularly for tomato growers in the southeastern quarter of the State. It is named "Wisconsin 55" and is derived from a series of crosses in which the varieties John Baer, Del Monte, Early Baltimore, and Redskin were used as parents. Seed of the F_8 generation beyond the final cross was first released generally to seed producers as foundation stock. Thus, a program, started in 1937, with evaluation trials of progeny beginning in 1942, finally resulted in a variety which appears destined for general commercial production.

The Minnesota station reports introduction of Faribo Hybrid E as a rival to the Earliana tomato, long popular as one of the best early varieties. After trials with Faribo Hybrid E, the New York (Cornell) station reports that this new variety may mature even a little earlier in New York than Earliana. The plant produces a spread of heavy, dark-green foliage, giving moderate cover to the flattened, globular, four-celled fruit with thick walls. The size of the fruit is small to medium.

For the home gardener in the North Central States, and perhaps in other locations, the South Dakota station advocates a trial of its new hybrid, South Dakota No. 2, that is described as a solid, meaty tomato of a size that is ideal for canning. It fits nicely into fruit jars without cutting. The surface of the fruit is smooth and free of cracks which adds much to the attractiveness of the canned product. It is one of the earliest tomatoes to fruit. Yield records in South Dakota indicate considerable promise there.

New tomato varieties have recently been announced in the Southern region. At the Florida station, Manahill is giving promise. Summer Prolific is the name given a tomato by the Texas station. It was bred especially for the West Cross Timbers area of Texas, a strip of sandy land just west of the Blacklands with an average rainfall of only 29 inches and with summer rainfall normally very light. From Louisiana favorable reports continue to come from the two tomato varieties developed at that station. Dixie, a large, pink variety with a small seed cavity is of value both for home and the commercial market in southern Louisiana. Louisiana Allseason has established a record for yield in the State.

The Arkansas station in 1949 released Fortune. Continued tests have established that Fortune is highly resistant to wilt, has a wide range of adaptability, and is especially well adapted to the needs of both can-crop producers and "green-wrap" growers in Arkansas. The fruit is of a dark-red color and desirable size.

From the Puerto Rico station comes the announcement of the new variety, Plamar. Plamar is becoming very popular for summer planting in Puerto Rico when the standard American varieties fail. It is estimated that from $90 to $120 per acre extra can be realized by planting Plamar rather than the old standard variety, Marglobe, in Puerto Rico.

Watermelons

The Tennessee station has introduced the watermelon variety, Miles, named in honor of the late Dr. L. E. Miles who was in charge of the breeding work at the Mississippi station when and where the original cross was made. The Miles watermelon is of the pedigree Dixie Queen × Klondike R7. The former is susceptible to fusarium wilt whereas the latter is resistant. The Miles is resistant to this disease, which heretofore has greatly hampered watermelon growing in Tennessee and many other States. Miles is reported to be equal in quality to any other variety, its sugar content is high, and its soluble-solids content excelled a number of other important varieties with which it was tested. Noteworthy is the bright, red flesh of Miles which is of a smooth texture and free from fiber.

The Missouri station, also aware of the dangers of fusarium wilt, has developed the Missouri Queen. Dixie Queen also enters into the parentage of Missouri Queen, which was obtained through inbreeding and selection in order to fix the desired characteristics. The Missouri Queen closely resembles the Dixie Queen in appearance. The marketable melons will average around 30 pounds and their shape is short-cylindrical. The rind is relatively thin but rugged enough to withstand shipping and handling in marketing. The flesh of the melon is a bright, rosy red, fine-grained, and free from fibers. The seeds are inconspicuous, being very small and white in color with tan tips.

Becoming popular in the North is Northern Sweet introduced by the Minnesota station. Northern growers prefer smaller and earlier watermelons. Northern Sweet meets this preference, although it is not adapted for shipping. The flesh is red-orange in color, of good quality, crisp, and sweet.

Purdue Hawkesbury is the name given a new watermelon bred by the Indiana station. It is more uniform in rind and has a better flesh color than the original Hawkesbury which came from Australia. Realizing the popularity of the so-called ice box melon, the California station has developed the Baby Klondike. Seed stock is now being increased by seedsmen and will be made available to the public.

In the North, the New Hampshire Midget, a product of the New Hampshire station's breeding research, is highly recommended by those who have seen it grow in trial gardens, especially for home use and roadside stands. Because of its reputation for quality, it is being used by plant breeders as far south as the Arkansas station. It is a very early, small, red-fleshed variety of good quality. It ripens well during hot weather, an attribute that is lacking with some varieties, particularly under home garden

conditions. Another introduction from the New Hampshire station is the variety, Colebrook. It is a new large-sized variety with some characters that were derived from the Orient and combined into a quality watermelon by the New Hampshire breeders.

Breeding New Ornamental Plants

Experiments in the improvement of ornamental plants have been carried on largely by commercial and amateur gardeners. With a few exceptions, State and Federal agencies have only recently engaged in the development of new ornamental trees, shrubs, and herbaceous plants. The difficulty encountered, however, in expanding private genetic and plant breeding activities over the long period required for ornamental trees and shrubs is becoming apparent. With trees it would be a long-time study that it does not seem practicable for commercial interests to undertake. The knowledge of modern genetics and plant breeding as applied to both trees and shrubs is now centered mostly in governmental and private research institutions.

State experiment stations have been responsible for the introductions of several noteworthy varieties of ornamental plants in the past few years.

Chrysanthemums

A chrysanthemum breeding project at the Minnesota station has given the people of that State a number of new attractive varieties that bloom sufficiently early to make them of great interest throughout the northern tier of States and as far south as Kentucky. The two latest introductions, Doctor Longley and Moonlight, bring the total up to 26. The former has large, amaranth pink to rose-pink, full double flowers, 2½ to 3 inches in diameter. The color does not fade in hot weather and has remarkable stability. The variety is very floriferous, blooming from early midseason until frost. The plant is of medium height. Because of its long stems, the flowers are excellent for vase use.

Moonlight is a white chrysanthemum with the center pale yellow to ivory. The plant is upright and bushy with large trusses of reflexed flowers up to 3 inches across. It blooms from midseason until frost. This variety is pleasing as a cut flower when large sprays are desired.

Roses

New roses are introduced usually by commercial companies, but the Minnesota station has developed several varieties that are considered particularly suited to the rigors of a northern climate. White Dawn is a low climber that may fill a need in many of the gardens of the United States. It is a cross of New Dawn and Lily Pons, both of which contribute to its hardiness. The new variety bears pure white blossoms against glossy, bluish-green foliage. It is reported to be a continuous bloomer and relatively resistant to disease. L. E. Longley is the second introduction de-

rived from a cross between Crimson Glory and Pink Princess. It is bushy and of the floribunda type so that it makes an attractive bedding rose. The flowers are semidouble, of good substance, bright red, with a very attractive bud. In Minnesota the plants remain in bloom from the middle of June until frost. The winter hardiness of L. E. Longley is noteworthy.

For those who prefer single-flowered roses, Red Rocket and Pink Rocket have been announced from the Minnesota station. These two varieties will make good border plants as they are vigorous and disease resistant. Of the two, Red Rocket is superior to Pink Rocket in size of flower, size of cluster, and intensity of color. Pink Rocket, however, furnishes Minnesota with a pink rose of the Rocket class, and it is as hardy and disease resistant as Red Rocket.

Junipers

The Iowa station has announced four new junipers, each of a different type, that should add variety to both foundation and border plantings in home beautification. These four new varieties were selected from seedlings of the Chinese Juniper. Ames, the first of these new junipers, is an upright but very slow grower. The mature foliage is green whereas the new foliage has a bluish cast. The foliage persists well into the center of the plant, and because of its dense, slow growth, very little pruning is needed. It is recommended particularly for individual specimen planting.

Maney is the second juniper from the Iowa station. This is a semierect type with foliage of a bluish cast. It grows as broad as it does high and, therefore, is recommended for landscape effects massed between high- and low-growing material. It stands pruning well and, therefore, can be restrained when necessary.

Iowa was selected as the third variety of juniper. It is somewhat similar to Ames but has considerably more freedom of growth and is neither as compact or symmetrical. It will find most favor as an informal background planting.

Finally the variety Story, was selected for introduction because of its characteristic growth habit with a dominant central leader. Its branches spread almost horizontal and bear dark-green foliage. This variety is recommended for novelty planting and where an unusual accent point is required in the landscape picture.

NEW VEGETABLE PRODUCTION PRACTICES

Development of better vegetable-growing practices has kept up with progress in plant breeding. New and revised methods of fertilizer management to effect economies and the possible expansion of the use of growth-regulating sprays are currently receiving considerable attention. The use of irrigation, even in truck crop areas where in the past the annual rainfall has been considered adequate, is becoming more common. New quick-freezing methods, as well as increased demands from the canning industry for improvement in vegetable production practices, have stimulated research in techniques to improve the quality of

produce through better handling, storage, and processing of vegetables.

Fertilizers for Vegetables

The Alabama station has recently shown that under certain conditions it is desirable to make several smaller fertilizer applications through the growing period rather than to apply all the fertilizer at one time. Where complete fertilizer was used in four equal applications, the yields of carrots were increased 274 percent where no manure was used, and 78 percent on manured plots. The yield of mustard was increased 147 percent on manured plots, and 258 percent without manure. These trials took place in an area of Alabama having a thin, sandy soil.

A study made by the Delaware station of 28 fertility and cultural treatments on asparagus showed that fertilizer applied at the rate of 800 pounds per acre produced yields almost comparable to 2,400 pounds per acre. The most productive fertilizer ratios were 1–1–1 and 1–2–3. Fertilizer was most efficiently utilized when one-half was applied in the spring and one-half immediately after the cutting season. Mounding the rows 6 inches high increased spear size significantly. A cover crop of buckwheat increased the total yield.

Arkansas research on the relative value of different fertilizer ratios showed that on tomatoes a 1–1–1 ratio gave the highest returns. The addition of nitrogen, phosphorus, and potassium, singly or in combination as a side dressing, did not increase yields. A 10–10–10 fertilizer at 500 pounds per acre increased the yield 98 percent over plots without fertilizer. The tomatoes followed a heavy crop of vetch, turned 1 month before setting the plants. Sweet corn, snap beans, and lima beans all reacted favorably to the 1–1–1 ratio. Southern peas, however, gave as great a yield with no fertilizer as with any of the fertilizer treatments.

The Ohio station conducted fertilizer trials on early cabbage, tomatoes, cucumbers, and sweet corn for 32 years in an intensive truck crop area of the State. The latest findings on this long-time project show that an application of 30 to 40 pounds of phosphoric acid per year is sufficient as a "maintenance application" on soils testing 200 pounds of available phosphorus. However, soils testing only 120 pounds of available phosphorus were not amply supplied with phosphate when a mixture with 120 pounds of phosphoric acid per acre was drilled prior to planting.

The Nevada station reports that phosphorus is an important factor in fertilizer applied to tomato plants that are to be shipped as transplants to eastern markets. Applications of fertilizer up to 1,000 pounds per acre showed that a 0–45–0 fertilizer at 400 pounds per acre gave the best results. Side dressings of ammonium nitrate did not increase the rate of growth and potash applications had no visible effect on the seedlings.

The Utah station sought to establish optimum fertilizer-application rates for a number of vegetables. Minimum rates of nitrogen and phosphorus resulted in the highest yields of peas of the

Perfection variety. Higher levels of nitrogen progressively decreased yield. Sweet corn, however, reacted differently. Applications up to 120 pounds of nitrogen per acre brought progressively higher yields. Fertilization trials of celery on intensively cropped vegetable land indicated that a potash deficiency may be the cause of a declining production.

Growth-Regulating Substances

The importance of timing in the application of growth-regulating "hormone" sprays to greenhouse tomatoes was emphasized in research at the Missouri station. By combining leaf pruning of staked tomatoes with a spray of *p*-chlorophenoxyacetic acid on the flowers of the plant after 3 to 5 flowers had been pollinated, tomato yields were increased as much as 50 percent. By such timing, softness of fruit was avoided. Softness appeared negatively correlated with seed content of the fruit, and it is reported that fruit with firm flesh requires as many functional seeds as possible.

The Pennsylvania station included greenhouse tomatoes in studying tomato fruit set both out-of-doors and under glass. During the winter months low yields of fruit in greenhouse tomatoes were attributed to low light intensities and short day length. This cause of unfruitfulness was overcome by a hormone spray, β-naphthoxyacetic acid, used as a concentration of 50 parts per million applied in the late bud or flower stage. This research also showed that a low yield caused by low temperature could, within certain limits, be overcome by the hormone spray treatment.

Outdoor tomatoes, set out at three different dates, were generally more fruitful both in early and total yields as a consequence of a hormone treatment with β-napthoxyacetic acid at 30 p. p. m. Also, the fruits from the hormone-treated plants were larger than those untreated.

At the Michigan station a water solution of *p*-chlorophenoxyacetic at a concentration of 30 parts per million was used on the first three-flower clusters of outdoor-grown tomatoes. Early and larger yields with larger fruit resulted. Treatments were first applied when flowers appeared on the crown clusters. This initial treatment was followed by two additional applications at 7-day intervals to flower clusters that came later. The response obtained is conditioned by the duration of time, after flowering begins, that night temperatures remain too cold for optimum fruit set.

When whole tomato plants, rather than just the flower clusters, were sprayed with one of a number of growth-regulating chemicals, it was found that the age of the tissue influenced the overall response of the plant. Early yield was generally suppressed in the treated plants which later in the season exceeded the yield of the plants not treated. It was concluded that such spraying of whole plants is of little practical benefit and may decrease rather than increase yield. Soft fruit was reported as more of a problem with tomatoes harvested from hormone-treated plants than with fruits picked from plants not treated.

At the Ohio station, 2,4,5-trichlorophenoxyproprionic acid sprayed on greenhouse tomato plants resulted in a consistent yield of fruits as firm as, or firmer than, those from untreated flowers. The reverse was true when *p*-chlorophenoxyacetic acid was used. With an outdoor staked summer crop a small increase in fruits per plant in the first cluster was recorded with some of the growth-regulating chemicals used; however, premature softening was apparent in tomatoes thus treated to an extent sufficient to warrant further investigations.

The Kentucky station reports a method whereby relatively high concentrations of urea can be sprayed on greenhouse tomato plants without danger of burning the leaves. This burning may be prevented by mixing equal molar solutions of sucrose with urea solutions. By this method up to 10 times as concentrated a solution of urea can be applied without injury. Tomato plants sprayed with this urea-sucrose mixture produced leaves with a higher sucrose content and fruit of improved quality and sweetness.

Irrigation of Vegetables

Research on the need of soil moisture for the growing of vegetable crops is being given increasing attention by experiment stations. It is contributing a considerable fund of information on the moisture requirements of specific crops. The Florida station was able to produce 2½ times more marketable ears of sweet corn on an irrigated plot than on a comparable check plot, without irrigation. This high yield was reported from a planting with a 12-inch spacing although wider spacing gave larger but fewer ears. The yield of carrot seed was increased by research performed at the California station. Under the climatic condition of Davis, Calif., a soil with a field capacity to a depth of 6 feet, from winter rains, was made more productive by additional irrigation water of about 8 to 12 inches. At the California station sweet corn yields were reported to be greatly reduced by insufficient soil moisture. Although the marketable ears were only slightly smaller, there was a pronounced number of ears that had no market value.

Yields of sweet corn from irrigated plots compared with check plots in the more humid climate of Alabama varied each year from 1944 to 1948. Although irrigation gave no advantage in yield in 1946 or 1947, the irrigated plots produced greater average yields than the nonirrigated over the 4-year period. Supplementary irrigation produced a marked increase in yield of tomatoes and snap beans in both 1948 and 1949, at the New York State (Geneva) station.

Quality of Produce

Because most vegetables are highly perishable, special attention is given to factors dealing with keeping quality in growing, handling after ripening, and processing for ultimate sale, of fresh, frozen, dehydrated, or canned vegetables. Moreover, reten-

tion of vital components such as minerals and vitamins in fresh-harvested and processed vegetables is a matter of concern to all.

The Maryland station found that the ascorbic acid content of Rutgers tomatoes increased slightly with increasing maturity of the fruit. Ascorbic acid content, however, diminished during the storage of "green mature" tomatoes at 70° F., also during storage of riper fruit at 35° and 50°. Tomatoes ripened in storage did not attain the ascorbic acid value of vine-ripened fruit.

In research aimed at improving the quality of pickles, the North Carolina station (coop. USDA) demonstrated that there are two enzymes associated with the destruction of pectin in dill pickles. These are pectinesterase and polygalacturenase. They cause undesirable softening of the product. Identification of these enzymes is expected to eliminate a major cause of spoilage of cucumbers, which annually causes the pickling industry considerable loss.

Merchandising of Vegetables

The development of large "supermarkets," with huge parking facilities nearby, is leading to improved merchandising in the vegetable trade. As a result of such facilities the consumer finds it convenient to buy larger quantities of fresh, canned, and frozen foods, and pays fewer visits to the market. Also, with increasing home refrigeration facilities, perishables can be purchased in larger quantities and stored ready for use. This trend in buying and selling vegetables, however, creates problems in transportation; storage by the grower, distributor, and retailer; and also problems in the various processing and preserving techniques.

Research at State experiment stations is solving some of the difficulties encountered in merchandising vegetables. The Florida station (coop. USDA), in a study made to determine the best types of containers in which to ship mature-green tomatoes by rail and truck, found that each type had its advantages and was satisfactory when properly handled. The study emphasized, however, the economic loss resulting from the lack of a standard container. A new hydrocooler to cool produce quickly has been developed at the Florida station. A shower of cold water was found to cool vegetables faster than immersion in cold water. Chlorine added to the cool spray was found to suppress the number of micro-organisms on the vegetables. These findings, together with the findings of a survey of the advantages of using ventilated plastic wraps in merchandising, provide information that should lead to increased returns from vegetables grown in Florida.

A study made at the New York (Cornell) station showed that circulating cold air at the rate of about 700 feet per minute cooled vegetables from 1½ to 18 times as fast as they could be cooled in motionless refrigerated air. With high humidity, loss of moisture under this rapid cooling was unimportant. Vacuum precooling of lettuce, broccoli, and sweet corn was also extremely effective. At the Ohio station the respiration of sweet corn and

tomatoes has been measured to determine factors that affect the shelf life of these vegetables. Those factors that quickly cause deterioration will receive attention in order to improve quality.

Because of reports from growers of failure of squash seed to germinate, the storage of squash seed has been studied at the Massachusetts station. The germination failure was found to be the result of harvesting seed from immature squash. The Massachusetts study did not support the belief that the germination of such seed could be improved by storage.

The New York (Cornell) station investigated the temperature changes that take place in prepackaged vegetables in refrigerated cases and on iced trays. It was shown that sweet corn and peas were slow to cool in display cases unless they had been previously precooled. Refrigerated cases were more satisfactory for display storage than were iced trays. Studies of the merits of various types of plastic wraps in lengthening shelf life and reducing moisture loss in several vegetables, showed that the kind of plastic wrap to use varied with the different vegetables studied.

The Iowa station (coop. USDA) has demonstrated that one cannot accurately predict the percentage of onions sprouting during the storage period, by making refractive index determinations of samples at harvesttime. By such readings, however, one can estimate the general level of sprouting in relation to other onion varieties.

A report from the Washington station showed that the ascorbic acid and carotene content of spinach, peas, and snap beans on a fresh weight basis was no greater when these vegetables were air-cooled prior to freezing than when they were water-cooled, under the conditions of the experiment. On the basis of the values as determined, however, more ascorbic acid was present in peas and beans immediately following air-cooling than after water-cooling.

The inheritance of longevity in the seed of sweet corn has recently been studied at the Iowa station. It was found that where two long-lived inbreds are crossed under ordinary conditions for seed storage, the resulting seeds are long-lived in storage. Where two short-lived inbreds are crossed, the seed is likewise short-lived. When long-lived and short-lived inbreds are crossed, the seed of the hybrid is long-lived. A study was made also at the Iowa station to determine when sweet corn kernels, being saved for seed, cease to accumulate dry matter. Seed harvested while still high in moisture may have poor finish and be light in weight, even though it may germinate satisfactorily. In a 3-year test all inbreds studied reached a constant dry matter of kernel stability where the moisture content was above 41 percent. It was concluded that when the kernels have reached 40 percent in moisture, no further gain in dry matter can be expected.

Also studying a problem regarding sweet corn seed, the Illinois station has reported that sweet corn seed with 35 to 50 percent moisture content cannot be safely dried at a temperature exceeding 100° F.; whereas if the moisture content is below 30 percent, a temperature of 130° may be safely used. It was reported that

a heredity factor is apparently involved in pericarp blistering and that artificial drying is not the cause of injury where drying is kept within the prescribed limits.

RESEARCH BRINGS NEW PRACTICES FOR ORNAMENTALS

Supplementing research on the breeding and improvement of flower and other ornamental plant species, investigations at some experiment stations are also under way with projects on ornamental plant culture, propagation, transplanting, and on the influence of certain gases on growth and the keeping qualities of cut flowers. Such research serves both the commercial flower growers and home gardeners.

Rose Culture

At the Ohio station research with roses continues to produce results that are of interest to all rose growers. Recent detailed anatomical studies there showed that root growth responses of roses are influenced directly or indirectly by the quantity of moisture present in the medium surrounding the roots. This research supplements early findings on the response of rose roots to aeration, fertilizer salts, and growing media.

The Ohio station also studied the influence of soil temperature on rose growing, as did the Illinois station. A soil temperature of between 60° and 65° F., was found to be most desirable.

Response of Flowers to Fertilizers

The North Carolina station (coop. USDA) reports that narcissus bulbs showed no significant responses to fertilizer applications the first year. During the second year, however, the same lots of bulbs under the same treatments showed significant differences. Best yields of early flowers and bulbs resulted from the use of either 1,500 pounds per acre of a 4–12–4 fertilizer or 750 pounds per acre of a 4–12–4 fertilizer plus a side application of 30 pounds of available nitrogen. The New York (Cornell) station fertilized newly transplanted ornamental plants with a starter solution in an effort to stimulate new growth in the field. Forsythia, yew, delphinium, and snapdragon plants placed in soils low in available nutrients were treated with 25 cc., of a starter solution consisting of 2 parts of mono-ammonium phosphate to 1 part of potassium nitrate diluted at the rate of 8 pounds of the mixture to 50 gallons of water. When the solution was applied at the time the plants were transplanted into the field, the results all demonstrated that there were no significant differences between the treated and the untreated plants. When the starter solution was applied up to 12 days before transplanting, however, significantly better plants were obtained, in the case of the yew, snapdragons, and delphiniums.

At the New Jersey station the boron requirements of greenhouse roses have been surveyed. In a study of greenhouse roses grown commercially in 16 States, it was found that deficiencies

existed in more than one-third of the greenhouse soils included in the survey. It was reported that flower yields can be reduced more than 10 percent when the supply of boron in a soil is inadequate.

Temperature and Light Effects on Flowers

The Wisconsin station completed research on the conditioning of azalea plants. More bushy and compact plants can be obtained by growing them in a cool temperature of 50° F., for 5 to 6 weeks during November and December. This treatment causes the axillary buds to become sufficiently large to produce "breaks" when the plants are removed to a warmer temperature. This procedure obviates the laborious and faulty plan frequently used to condition azaleas—that is cutting or pinching back the plants.

The Illinois station, in an attempt to discover means of increasing production on greenhouse roses, found that defoliation does not help to promote increased flowering. Although defoliation produced double the number of shoots over the checks, these shoots were vegetative and the defoliated plants produced fewer flowers.

The influence of length of day on certain ornamental plants is being studied by several experiment stations. At the Michigan station, China-asters were grown at temperatures of 50° and 65° F., and each group was subjected to long- and short-light periods. Both the time of initiation of flower buds and the time of actual flowering were influenced by the length of day and the temperature. The New York (Cornell) station made a study on the control of the type of pompon chrysanthemum sprays by changing the photoperiod during flower bud induction and development. Two types of flower sprays were produced by this method, both of which were considered superior to the normal spray produced by a continuous short photoperiod. Quantitative studies on chrysanthemums to determine the number of short photoperiods required for flower bud initiation have also been completed at the Cornell station. For the chrysanthemum variety, Gold Coast, 3 to 4 short-day photoperiods, 14 and 24 days after pinching, were sufficient to initiate flower buds.

Because both temperature and humidity can markedly affect the longevity of pollen, the California station made a study of Hemerocallis pollen as a means of furthering the effectiveness of breeding this plant. Pollen stored at 3° C. and a relative humidity of 10 percent remained viable for at least 3 months, whereas pollen stored under uncontrolled temperature and humidity lost its viability before the eighth day of storage.

Propagation and Transplanting

An investigation of the possibility of inhibiting the formation of basal callus and roots in propagating *Taxus cuspidata* cuttings was made at the New York (Cornell) station, when powdered Fermate was used with two growth-regulating substances. Earlier reports had shown that Fermate has a stimulating effect on roots, but in a test of cuttings of *T. cuspidata* under the conditions

of the experiment the reverse was found to be true. In an effort to find the most effective synthetic growth substance for the rootings of cuttings, the Michigan station has reported studies covering a number of the more promising chemicals. With cuttings of several deciduous shrubs, certain advantages are indicated with triethanolamine β-napthoxy acetate, both from the number of cuttings rooted and the more normal type of roots induced.

The use of a plastic resin spray to increase survival of summer-transplanted evergreen under severe conditions has been studied at the Michigan station. Although the work done is preliminary in nature, a number of nurseries in Michigan have adopted the technique and have reported favorable results.

Effect of Gases on Ornamentals

Some gases are decidedly detrimental to ornamental plants and flowers, particularly those grown in greenhouses or those in storage under a confined atmosphere. At the New York (Cornell) station, it has been established that both snapdragons and calceolarias can produce a toxic, volatile gas, suspected to be ethylene. This gas causes flower-drop on both of these plants and may be the cause of early deterioration of cut flowers held in confined space or in cold storage. A high oxygen or low carbon dioxide atmosphere also was found to increase flower-drop, whereas flower-drop decreased with a high content of carbon dioxide in the air.

Even flowers growing outdoors are not immune to damage from toxic gases. The Oregon station has reported that fluorine-containing fumes from nearby aluminum reduction plants can cause damage to gladiolus. In controlled experiments it was found that exposure to an atmosphere containing from 0.1 to 2.0 parts per billion of hydrogen fluoride for periods lasting from 2 to 20 days caused leaf symptoms similar to those found on gladiolus in the field near factories from which the fumes emanated.

Other research with gases has been concerned with the response of plants whose roots are subjected to various concentrations of oxygen and carbon dioxide. At the Ohio station studies with greenhouse roses have shown that roots of plants function equally well in oxygen concentrations of from 1 to 29 percent and carbon dioxide concentrations up to 20 percent. Anatomical studies showed, however, that some of the concentrations, away from the optimum, caused distinct changes in the structure of the plants. Further research showed that when the soil was aerated with gas mixtures containing 1 to 29 percent of oxygen the greatest growth of tops occurred at concentrations of from 9 to 17 percent.

RESEARCH ON PLANT DISEASES AND THEIR CONTROL

The scope of research aimed at discovering the nature of plant diseases, and of practical and economical methods for their control, as carried on by the State experiment stations, may be meas-

ured by the amount of the total annual budget in this field. In 1949, State experiment stations reported total expenditures for plant disease research amounting to 2½ million dollars. Closely cooperating in many of these projects are the Department and private industries, such as those engaged in pesticide manufacture.

Many of the new crop varieties reported in the preceding pages are the result of much combined effort on the part of plant pathologists and plant breeders. Examples of numerous researches dealing with diverse plant disease problems and their control, including some additional examples of plants developed to resist specific diseases, are reported in this publication.

Diseases of Field Crops

Wheat diseases

Stinking smut or bunt, one of the most destructive of the soil- and seed-borne diseases of wheat, is especially troublesome in the far West. The Utah station (coop. USDA) met this problem successfully by developing two bunt-resistant varieties, Cache and Wasatch, adapted to conditions in Utah and southern Idaho. In 1949 some $26,000,000 worth of these two varieties was grown in these two States and the percentage of carloads grading as smutty dropped from a high of 60 percent in 1935–36 to 5 percent in 1948–49. Research is continuing to increase the total bunt resistance and to improve other qualities in types of wheat adapted to the area. Some idea of the size of the task is indicated by the fact that about 15 different races or strains of the bunt fungus are being used in testing for resistance with the hope of combining resistance to many bunt races in the better lines of wheat.

The distribution and seriousness of a recently recognized disease of wheat caused by the organism *Pyrenophora* sp. was found to be greater in Kansas during 1949 than it was in 1948. The parasite is potentially dangerous because it attacks other crops besides wheat. Certain varieties of barley, oats, and several inbred lines of corn were found by the Kansas station to be susceptible to this parasite.

The Minnesota station (coop. USDA) determined the reaction of 2,338 varieties and selections of wheat to bunt, scab, root rot, stem and leaf rust, and black chaff and to insect injury, by growing this material in a disease garden. In this way a large number of the disease-susceptible selections were eliminated in the early generations, leaving a smaller number of disease-resistant lines to be studied more intensively.

The arduous task of inoculating large numbers of individual heads of the cereal grains with the loose smut organism in testing for smut resistance may be made much easier and done much more rapidly by the high-pressure jet method developed at the Minnesota station. An investigation is now being made to determine whether the introduction of contaminating scab spores into the liquid used for inoculation may be prevented by the use of an air jet.

The Ohio station has shown that the time of day and the length of time the flowers of certain wheat varieties remain open have an important bearing upon the susceptibility of varieties to scab head blight, *Gibberella zeae*. Florets of the resistant Trumbull variety are open only during the comparatively dry daylight hours, whereas the florets of the susceptible varieties Butler, Thorne, and TN–1016–4 are open during the early and late periods of the day when the relative humidity is high, a condition which is conducive to increased infection. It should be possible, therefore, through selection to pick out a desirable scab-resistant wheat.

Using Hope and H44 varieties of wheat that carry resistance to several important diseases, the Washington station (coop. USDA) found that the genes for leaf rust and mildew reaction in these two wheats are linked with about 25 percent crossing over. Stem-rust reaction appears to be conditioned by two main genes. Evidence obtained from triangular crosses involving Hope, Thatcher, and Triunfo indicate that three genes for leaf-rust reaction are involved, and that if these are combined in the proper manner, a high degree of leaf-rust resistance is secured. The station has also been able to transfer the smut resistance of Hymar to the desirable Elgin wheat. These findings contributed basic information used in the development of the new smut-resistant varieties Elmar, Brevor, and Marfed.

That early fall seeding of winter wheat will greatly reduce losses caused by snow mold was shown by the Washington station. In some years in Douglas County alone, this organism has caused losses up to $300,000.

In Kansas the wide use of the new leaf rust-resistant varieties of wheat, Pawnee and Comanche, prevented heavy losses from this disease in 1949, although the infection on nonresistant varieties was the heaviest in many years. Rust development of such severity would have caused a loss of at least 20 percent if later, less resistant varieties had been used; but estimates made by the Kansas station showed that the losses with rust-resistant varieties were actually less than 10 percent. Through its studies of leaf rust epidemics over a period of years, the Oklahoma station can now usually predict serious outbreaks of leaf rust in time to warn farmers to replant with grain sorghums wheatfields certain to be seriously damaged by leaf rust. In this way the farmer is reasonably sure of an income from one crop or another.

The Minnesota station found that wheat plants infected with rust lose more water, especially at night, than noninfected plants. They also found that some of the new wheat varieties were highly or moderately resistant to stem or leaf rust at low temperatures and susceptible or moderately susceptible at high temperatures. This will help explain why rust may be troublesome some years and almost totally absent in others. In further work on the identification of parasitic races of stem rust of wheat by the Minnesota station (coop. USDA) 17 races of rust were obtained in 1949 from 669 rust collections on wheat from the major wheat-growing areas of the United States, races 56, 17, and 38,

in the order of prevalence, comprising more than 90 percent of all isolates. On the other hand, 35 races of stem rust were obtained from only 96 collections made from rust infections on the barberry. This clearly indicates that stem rust from the barberry is potentially more dangerous than rust from grain, since new races capable of attacking improved wheat varieties are more likely to originate on the barberry. It is, therefore, wise to get rid of the barberry as rapidly as possible.

Out of 1,639 varieties of foreign wheats tested cooperatively by the Texas station (coop. USDA), 43 varieties of common wheat were found which had resistance to stem rust in various degrees, and 13 of these were also resistant to leaf rust. Especially promising were those varieties obtained from Kenya. The new stem-rust resistant Quanah variety, mentioned in the chapter on field crops, p. 8, has special significance from a national standpoint. It can be grown in those sections of Texas where leaf and stem rusts often overwinter and where they sometimes develop into early epidemics that may spread North.

Mold spores on wheat killed at 250° F.—The Minnesota station in studies on the role of contaminating micro-organisms in the processing of wheat and wheat products, found that if flour was heated up to 250° F., most of the mold spores would be killed. Wheat flours are widely used as thickening agents in the canning industry and are a source of heat-resistant bacterial spores derived from the soil during growth and harvesting of the wheat. Flours containing from 2 to 74 thermophilic spores per gram and used in canned goods did not cause spoilage provided the flours were heated to 250° F. Further research by the Minnesota station on storage of wheat has shown that in inert atmospheres of nitrogen and 20 percent of carbon dioxide the viability of the wheat seed was greatly prolonged when the moisture content of the seed did not get above 14 percent. In contrast, samples stored under air at 14 percent moisture had markedly decreased viability and later became completely nonviable.

Diseases of oats

In 1949 an apparently new and serious disease was attacking oats wherever this crop was grown in the United States. A reduction of 12 percent in yield of oats in 1949 compared with 1948 was attributed in large part to this new disease which has not yet been fully identified. Investigations by the experiment stations (coop. USDA) indicated that all varieties suffered, although in general the older varieties withstood the disease better than the newer, more recently developed ones. The most striking symptom appears to be reddening of the leaves. Research was begun to determine the cause and possible means of prevention.

According to the Arkansas station, there was more crown rust on the susceptible oat varieties in 1949 than there was in 1948. However, the State as a whole suffered very little loss from this rust disease because most of the acreage was planted to Traveler, a superior rust-resistant variety developed by the Arkansas station, and to other rust-resistant varieties.

Rice diseases

Research at the Arkansas station has shown that treating rice seed with Arasan and Ceresan M when the rice is to be drilled into the soil, and with Yellow Cuprocide when the seed is to be planted in water, will result in significant increases in stand and yield. It is estimated that between 50,000 to 75,000 bushels of seed rice were so treated in 1949, and on the basis of an increase of one bushel per acre, $75,000 was added to the income of Arkansas rice farmers.

The Arkansas station reported last year that the damaging disease known as white tip of rice is caused by a species of nematode which is carried in the rice seed. Treating the seed for 15 minutes with hot water (following the method used in controlling loose smut in cereals) will control the disease. An increase of 10 bushels per acre was obtained when Arkrose seed was so treated before planting. It has also been shown that the eelworms causing the disease do not survive in the seed longer than 12 to 15 months, and excellent control of the disease was obtained when infected seed was held in storage for 20 months before it was planted.

Barley diseases

In studies on net blotch, an important disease of barley in northwestern Minnesota, the station found that in order for the disease to develop in epidemic proportions, a 40-hour incubation period of high humidity was necessary, followed by at least 4 days of high soil moisture. Because of this knowledge, plant pathologists are now in a better position to anticipate destructive outbreaks of net blotch.

The North Carolina station found that all collections of powdery mildew disease of barley in the State in 1946 were identified as race 6. Of the collections made in 1947, however, 60 percent were race 6, 30 percent were race 9, and the remainder race 4. In contrast, all collections from North Carolina in 1949–50 were race 9. Indications are that race 6 is decreasing in prevalence and race 9 is increasing in prevalence in this State, and varieties used should now possess resistance to this race.

Diseases of corn

The soil-borne fungus, *Pythium graminicola,* according to the Iowa station, is a major parasite of the roots of corn responsible for lowering yields. Lines of corn differ in susceptibility. Evidence to date indicates that cultivated corn land contains much more of this fungus than adjacent land in sod, thus helping in part to explain the better corn crops produced in a good rotation. Another contribution of this Iowa study establishes the fact that root parasitic nematodes are much more common in Iowa soils than heretofore realized.

Flax diseases

The Minnesota station found that chlorosis (lack of green color) in flax can be controlled by spraying the plants with solutions

containing iron. Yields of field-grown Dakota flax were significantly increased in this way.

Flax wilt has long been one of the principal diseases of flax, and great progress has been made in developing wilt-resistant varieties. However, the factors that affect wilting have been little understood. In a study of some of these factors, the Minnesota station found that certain varieties of flax wilt more on dry soil whereas others wilt more on wet soils. Fifty-four percent of the plants of a given variety wilted in loose soil compared to 85 percent on hard, compact soil. Wilting of Royal and Crystal flax was checked by soil applications of superphosphate, whereas the addition of lime checked wilting in Crystal, Royal, Bison, and Redwing varieties of flax.

Weather conditions are often unfavorable for the rapid development of a natural anthracnose epidemic necessary to test the susceptibility and resistance of large numbers of flax varieties and selections of a crop. The Minnesota station overcame this difficulty by developing a quick test. Seeds were germinated in wet, folded blotters, then dipped in the fungus suspension and were planted, blotter and all, in the field. Infection varied from less than 25 percent in resistant varieties, like Minerva and Crystal, to 100 percent in susceptible varieties, like Bison and Dakota.

Potato diseases

The potato is one of the most staple foods of the American people. If a crop such as the potato is to be produced efficiently, as many of the production hazards as possible should be eliminated. A good deal of time, money, and effort is expended each year in improving the quantity and quality of this highly nutritious crop and lowering the cost of production through research on the control of its many diseases. The practical value of results is increasingly evident from year to year.

Potato Scab.—This has long been one of the chief diseases of potatoes. The lesions and blemishes that the scab organism produces on the surface of tubers has a marked effect on their acceptance by the consumer. The soil conditions associated with scab have been puzzling. It has generally been assumed that scab will not develop on tubers if the soil is very acid, testing pH 5.2 or lower. The Connecticut Agricultural Experiment Station at New Haven found, however, that potatoes frequently will scab even in soil as sour as pH 5.2 and often do not scab even though the soil is less acid than pH 5.2. In seeking an explanation, the Connecticut station found that calcium increases scab regardless of its influence on hydrogen-ion concentration. Likewise, hydrogen decreases scab, irrespective of its effect on calcium-ion concentration. The Indiana station showed in experiments on muck soils that as the extractable aluminum content of the soil increases, the severity of scab decreases. This indicates that active aluminum-ions rather than hydrogen-ions are the effective agents in potato scab control in acid soils. Parasitic races of the scab

organism that will grow satisfactorily in culture at the low pH of 4.4 were also found. The addition of 20 parts per million of aluminum, however, prevented growth of the scab fungus in culture below pH 5.1. These discoveries point to new control measures against the disease.

Scab can also be controlled through the development of resistant varieties, and substantial advances along this line have already been made. The new scab-resistant potato variety, Progress, developed by the Nebraska station (coop. USDA), was grown on 2,000 acres in Nebraska during 1949.

Late Blight.—During the past 2 years, the Louisiana station has secured information that helps explain the sudden outbreak in 1948 of late blight simultaneously on tomatoes and potatoes, and its attack in 1949 on potatoes only. Certain cultures of the late blight organism isolated from potatoes in 1948 attacked tomatoes, although none of the 1949 isolates from the same host caused blight in the tomato. It is probable that the 1948 epidemic of late blight on tomatoes and potatoes was initiated by the tomato strain which lived over in Louisiana on either tomato or potato from the previous season. The 1949 epidemic on potatoes, on the other hand, originated from the potato strain, believed to have been introduced on seed potatoes from the North, since there was no evidence that late blight lived over locally on the fall crop of potatoes in 1948.

New Protective Treatments for Potato Seed Pieces.—Much loss has recently been experienced in Oregon as well as elsewhere by the decay of potato seed pieces in the soil after planting. In an investigation of this condition and in experiments with different methods of treatment as a means of reducing this decay, the Oregon station found that the most effective method tested was the dipping of freshly-cut seed pieces in either Phygon or ziram. These are new types of organic fungicides developed by the American chemical industry in recent years. In comparison with the success obtained with these new materials, seed pieces treated with older standard mercurial types developed complete breakdown unless planted within 72 hours after treatment. In Oregon a species of *Fusarium* is the fungus most commonly met in connection with seed-piece decay.

Minnesota station investigations on tuber rot infection showed that careful handling is essential if bruising is to be prevented, and wounds necessary for the entrance of tuber-decaying organisms thereby eliminated. It was found that when 196 tubers were shaken in a wire basket to injure the tuber slightly, 65 became infected. On the other hand, of 196 comparable tubers that were not bruised in this way, only 3 became infected.

Ring Rot of Potatoes.—This highly infectious bacterial disease is gradually being brought under control through the cooperative efforts of the Department and several State experiment stations. The testing in the greenhouse by the Maine station of over 13,000 seed tubers for freedom of ring rot and other tuber-borne diseases has helped the Maine foundation-seed growers to maintain disease-

free seed stock. The Wyoming station found that by treating ring-rot-infected seed pieces with streptomycin, surface contamination as well as some possible natural infection of tubers was eliminated. It was also learned that susceptible varieties, such as Bliss Triumph, can carry ring rot bacteria without detection for periods of 3 years or more before the plants show disease symptoms. The most effective means of control probably will be through the development of resistant varieties. The use of Teton, Erie, B–355–23, and other resistant varieties as parents has enabled the Maine station (coop. USDA) to make rapid progress in transferring this resistance to varieties that yield well and that are of high quality.

Combating Potato Virus Diseases.—State experiment stations (coop. USDA) are studying the numerous virus diseases of the potato that are responsible for lowering yields and in some cases discoloring affected tubers. The Maine station found that spindle tuber is readily transmitted by seed-cutting knives and by contamination of small sprouts on the seed tubers prior to planting. The spread of this disease was reduced by treating the contaminated seed stocks with sodium hypochlorate solution or by drying the cut seed pieces prior to planting.

Research on purple-top wilt of potatoes by the Minnesota station has shown that the aster yellows virus is at least a component factor in the cause of purple-top wilt. The station also found that this disease is rarely transmitted through seed pieces, as only 1 percent infection occurred in 1948 and 1949. When tubers from purple-top plants were used for seed, approximately 10 percent failed to sprout, 10 percent produced spindle sprouts, and another 20 to 30 percent produced weak plants. However, the distinguishing symptoms of purple-top wilt were lacking.

Research at the New York (Cornell) station dealt primarily with the development of improved methods for the detection of viruses in the potato plant and with determining how these viruses affect other species of plants. They found that virus infection results in greatly increased ethylene production in certain infected plants. When potato plants are inoculated with both virus X and virus Y, the resultant symptoms are much more severe than would be expected upon the basis of symptoms produced by each virus alone. This increase in severity of symptoms is associated with a marked increase in the amount of virus X. The doubly infected plants may contain as much as 10 times the quantity of virus X as do plants infected with virus X alone.

Two-purpose Potato Spray Combination.—The Maine station found that a spray combining 4 pounds of basic copper sulfate in 100 gallons of water with 1 quart of oil emulsion containing 24 percent DDT and 1 percent parathion, gave excellent control of both diseases and insects. When dust fungicides were used, best potato yields were secured when applications were made under what has been considered to be adverse conditions; namely, during the middle of the day when the foliage was dry and the wind was blowing.

Sweetpotato diseases

Extensive experiments conducted at the California station on fusarium wilt or stem rot of sweetpotatoes showed that wounds involving the water-conducting elements of the plant were necessary for infection. The fungus that causes this disease enters only through freshly cut stems, roots, or fresh leaf scars, but not through uninjured stems or roots, root eruption wounds, stomata (skin pores), or the callus of a healed basal wound.

Sweetpotato sprouts in plant beds in southern New Jersey for a number of years have shown a brown decay which in severe cases prevents emergence and in mild cases results in twisted sprouts. Sprout decay has caused total failure in about one-fifth of the beds and about 80 percent have shown typical injury. The cause of the trouble remains obscure although it is evidently associated with the soil. Broadcasting as much as 1 ton of superphosphate per acre resulted in a nearly perfect stand. Use of 1,000 pounds also resulted in excellent stands although the height was not uniform.

The Louisiana station is studying the virus-induced internal cork disease which is causing much concern in the South. Records taken over 3 years on samples of sweetpotatoes grown from stocks exhibiting ring-spotting of the leaves and from stocks showing "corky" roots indicated strongly that the agent that causes cork is distinct from that causing leaf-ring-spot or that possibly a combination of two separate viruses may occur. Certain clonal lines showing leaf spot were grown for 3 years without showing cork symptoms in the roots.

Improved cottonseed treatments

Poor seed germination and seedling blights have been lessened by the development of more effective methods of seed treatment. The North Carolina station reported highly successful results with a chlorinated zinc phenol compound which is less troublesome to operators than certain other standard materials and, as proved by South Carolina tests, of little danger to animals fed with treated seed. It is estimated that this treatment makes it possible to use 10 to 15 pounds less of seed per acre planted than formerly practiced. Greenhouse and field experiments conducted for 3 years by the North Carolina station failed to show any clear evidence of significant growth stimulation from hormones used as seed treatments. The Arkansas station has proved that, under some conditions, expensive thinning (chopping) of cotton can be discontinued by planting treated seed, 5 to 8 per foot, with proper machinery. Seed treatment probably added 22 million dollars in 1 year to the value of the Arkansas cotton crop. Oklahoma station tests have shown that seed treatment almost eliminates bacterial cotton blight in the seedling stage.

Tobacco diseases

No important tobacco-growing area exists in the United States where growers are free from large losses caused by various types

of infectious tobacco diseases. The experiment stations in tobacco-growing States, with USDA collaboration in many cases, are conducting continuing research programs to find answers to specific disease problems. Tobacco growing in many productive areas would long ago have had to be given up had not ways of preventing or reducing the damage from chronic disorders and sweeping epidemics been developed.

Much has been done to build up resistance of tobacco to virus diseases by breeding strains that will not be badly affected by mosaic or streak. The California station reports the development of a method for successfully transferring mosaic resistance from wild to cultivated tobacco types. The Kentucky station has tested plants of 46 different species of *Nicotiana* for their resistance to the streak virus and 45 species for resistance to the mosaic virus. Two wild species offer special promise as sources of streak resistance. One species showed no symptoms of mosaic after inoculation.

Although the practice of spraying with bordeaux mixture, as developed years ago by the Kentucky station, serves to keep in check the bacterial disease wildfire, the disease still plays havoc, under ordinary circumstances, in seasons when weather conditions such as excessive rains are favorable to development of the organism. Hence, the Kentucky station is seeking sources of wildfire resistance to use in its tobacco-breeding program. Six out of forty-six species of *Nicotiana* tested have showed resistance. These will be used by plant breeders in the hope of getting rid of the wildfire menance. The Pennsylvania station (coop. USDA) is working along similar lines.

Soil Treatment Lessens Tobacco Damage.—Soil fumigation is coming to the fore as a means of reducing the weed and disease problem in tobacco beds. Several experiment stations are studying the cost and effectiveness of preparatory treatment of soils in connection with the planting of different types of tobacco under different soil and climatic conditions. Recently the Connecticut Tobacco Laboratory showed that damage to the Havana seed crop from root knot and meadow nematodes can be reduced by injecting ethylene dibromide into the soil. This treatment also improved the duration of burn of the tobacco. The North Carolina station found that methyl bromide gas used in adequate strength as a soil fumigant or drench was effective against both weeds and the black shank disease. When chloropicrin was added, it also controlled root knot nematodes. A spot survey in 1949 in eastern North Carolina showed that nearly half the tobacco fields suffered nematode damage.

Tobacco "frenching" or strap leaf is an erratic disorder of tobacco that is associated with high temperatures and high moisture in certain soils and certain seasons. A severely affected plant is bushy, stunted, has dagger-like leaves, and is a total loss. Research in a number of States has failed to reveal the precise cause or a reliable means of prevention. The Massachusetts station has conducted fundamental research in an effort

to find a practical solution. The station found that a certain unknown substance must be present in the soil before the disorder can appear. The "frenching factor" can be present in soils that have never grown tobacco and can affect plants other than tobacco. Although the effects of frenching resemble some of the effects of nitrogen deficiency, high nitrogen supplies do not prevent or correct the trouble. The use of certain chemical soil fumigants, however, appeared to eliminate the factor in experimental trials.

Sugar beet seedling blight

Several stations are working on the sugar beet seedling blight problem. The Montana station has recently reported a great reduction in loss from this cause through the treating of soils of low fertility with a properly balanced fertilizer and animal manure at seeding time. The Colorado station has found chemical seed treatment a help. The Nebraska station demonstrated that the organic fungicide thiram applied in bands alongside the planted seed considerably improved the stand. Long rotations, in which beet plantings on the same ground were made several years apart, also reduced the damage from soil organisms.

Preventing death of sugarcane seed pieces

Extensive research at the Louisiana station has shown that the cause of the dying of sugarcane seed pieces after planting is a soil-borne fungus of the genus *Phytophthora*, a relative of the potato late blight organism. Steps are under way to apply this research in cane breeding for resistance to this fungus as a means of control. In soils where pythium root rot of sugarcane was less troublesome than elsewhere, the station found higher percentages of Actinomycetes antagonistic to the causal organism. This finding may lead eventually to new soil management practices that will take advantage of the antibiotic activity of these microorganisms to reduce root rot damage.

Peanut mosaic, stem blight, and nematodes

During the year the North Carolina station announced the finding of a severe and a mild form of mosaic disease of peanuts that are apparently capable of rapid spread by insects. The virus nature of the infections was proved. Their possible effects on the industry and how to control them are being investigated further.

One of the most feared and baffling of peanut diseases, the erratic, often destructive southern blight or wilt (Rolf's disease) was found by the Virginia station to be much more severe where peanuts follow legume crops, like soybeans or peanuts, than where peanuts follow a nonleguminous crop like corn, cotton, or rye. Georgia and the North Carolina stations found that soil treatments did not give protection against this disease. The Texas station discovered a number of unblighted individuals under

severe blight conditions, among some 2,000 plants of varieties and selections, mostly of Spanish origin. This station developed a very speedy way of multiplying these resistant peanut plants by using hormone-dipped stem sections with one leaf and bud attached.

The Georgia station found meadow nematodes in the roots of peanuts, a crop generally considered resistant to these minute root-invading pests. Evidence was obtained that peanut shells used as mulch may carry nematode contamination to new places. The North Carolina station investigated a severe stunting in peanuts and found that it is caused by a strain of root knot nematode. This could, however, be completely controlled by ethylene dibromide or dichloropropene and dichloropropane used as soil fumigants. Tests with 16 improved strains of peanut showed none to be resistant either to nematodes or southern blight.

Diseases of Forage Crops

The maintenance of maximum production in a rapidly expanding, soil-conserving grassland agriculture in all parts of the country depends to a large extent on understanding the factors that may affect the development of the more important diseases of forage crops. Experiment stations are devoting a considerable amount of effort to studying these factors in order to find satisfactory control measures.

Good nutrition essential for healthy grass

The South Dakota station (coop. USDA) has demonstrated that lack of proper plant nutrition predisposes forage grasses and cereals to browning root rot. Prevalence of the disease is accentuated when the soil is deficient in nitrogen.

Cadmium controls turf diseases

One of the most important causes of a "ragged" lawn are the diseases which begin to kill the grass blades in early spring. Still other grass diseases are more destructive during the warm, humid summer months. The Rhode Island station discovered that certain cadmium compounds are effective in controlling the more important diseases of turf.

Soybeans should follow cereals and potatoes in rotations

The Minnesota station in its research with *Rhizoctonia solani,* one of the root-rotting organisms of soybeans, learned that the crops included in a rotation may have an influence on the extent of root rot present in the subsequent soybean crop. Specimens of *Rhizoctonia* obtained from flax and legumes spread the disease to soybeans more rapidly and widely than did specimens taken from cereals and potatoes. This indicates that to reduce the amount of root rot it may be desirable to precede a soybean crop with one of the cereals or potatoes rather than with a legume or flax.

Legume seed treatment

Seed treatment of soybeans with several fungicides at the Minnesota station gave increased stands although in these tests yields were not improved. However, because a high percentage of available soybean seed is mechanically damaged and is especially subject to decay in the soil, seed treatment of this crop is now recommended in Minnesota. Similar tests with alfalfa, red clover, and sweetclover showed that seed treatment is usually ineffective on Blue Tag certified seed, but is effective with poor quality or scarified seed. Furthermore, seed treatment did not prevent the necessary root nodulation, provided the seed was inoculated before the seed was chemically treated.

"Black patch" of clover in West Virginia

A fungus disease known as "black patch," considered to be comparatively harmless in Kentucky and Wisconsin, where it was first discovered some 15 years ago, is now recognized as a serious disease of clover in West Virginia. The fungus is seedborne and when infected seeds are planted, the resulting seedlings are killed. Thus, the fungus may cause severe seedling blight as well as a blight of the leaves, stems, and flowers. The disease is favored by high humidity and spreads rapidly at relatively low temperatures. Under conditions prevailing in the South Branch Valley, the West Virginia station found that in 1948 and 1949 black patch was very destructive and it was obviously an important limiting factor in clover production. Seed production was reduced considerably more than 50 percent in some fields during those two years. The findings point to the great importance of planting disease-free seed in areas subject to black patch.

Orchard Fruit Diseases

American orchardists probably spend more time and money fighting apple scab, cherry leaf spot, and stone-fruit brown rot than all other fruit diseases combined. If it were not for the spray programs developed by research, commercial orcharding in many areas would have to be abandoned. But spraying is costly and State experiment stations, in close cooperation with the Department and the chemical industries, are continuously testing materials and seeking new ones that may reduce operational costs. Likewise improved spraying equipment and other machinery adapted to practical, economical orcharding are being devised. Naturally, much of this research is directed at specific area problems of adapting improved fungicides and control practices to different soil and climatic conditions and to the varieties grown in each area. A few of the more recent researches for better orcharding are here reported.

New sprays for apple diseases tested

In 1949 station experiments for better control of scab and other apple diseases in different parts of the country included

trials of various fungicides. Among these were ferbam; 2,3-dichloro-1,4-naphthoquinone (Phygon); sulfur-bordeaux; ziram; phenyl mercury acetate (Tag HL331); phenyl mercury triethanol ammonium lactate (Puratized); glyoxalidines (Crag 341–C); bis (2 hydroxy-5 chlorophenyl) sulfide (CR 305); organic cadmium (H-258-A); copper 8-quinolinolate (Bioquin 1); dinitro-*o*-cyclohexyphenol, dicyclohexylamine salt (DN–111); dinitro capryl phenyl crotonate (Arathane); and N-trichloromethyl thio-tetrahydrophthalimide (SR 406).

Use of any such sprays should carefully follow precise directions of the State experiment station to forestall damage to the orchard.

The Maine station found CR 305 and H-258–A to be injurious in that State to the apple foliage, whereas a Phygon-sulfur mixture gave excellent scab control with no report of injury and Crag 341–C also performed well. Tests by this station on the use of several materials in concentrated form gave promising results. Among these may be mentioned concentrated sulfur sprays which appeared economical and feasible for the orchardist.

The Rhode Island station, experimenting with combination sprays for apples, found it safe, in a prebloom spray for McIntosh, to mix phenyl mercury and organic cadmium fungicides with old or newer types of oil emulsions; and the same procedure proved effective for Puratized combined with DDT or with dinitro-*o*-cyclohexylphenol, dicyclohexylamine. On the other hand it killed leaves and reduced yield if combined with a summer spray oil. Phygon-XL controlled scab without russeting Baldwin fruit.

Phygon controlled scab better in North Carolina trials than ferbam but, unlike ferbam, delayed fruit maturity 2 weeks or longer than a sulfur-bordeaux spray. Bordeaux, although causing some leaf drop of Red Delicious and Black Twig apples, controlled bitter rot and black rot best.

The Pennsylvania station experimented with concentrated sprays applied by air blast. With only 15 percent as much water as in standard sprays, a sulfur paste 3½ times normal gave almost perfect scab control with about 40 percent saving in sulfur. Some leaf injury resulted with this spray. When mixed with ferbam, however, sulfur paste gave good scab control with little injury. The organic mecurials, Phygon and Crag 341–C gave better scab control than standard sulfur paste used alone or with ferbam, although the former were more injurious under some conditions and are not recommended after fruit is set.

In laboratory tests with four plant pathogens, the Illinois station in 1949 screened some 200 new chemicals for possible usefulness against plant diseases and checked their safety on bean foliage. About 30 of these were worthy of field trials in 1950 against apple scab. In apple scab field tests it was found that Bioquin and sulfur boost each other's effectiveness against scab. Crag 341–C, as well as Bioquin 1, proved effective against bitter rot, black rot, and sooty blotch. Crag 341–C appeared somewhat toxic to mites.

The Ohio station reports Crag 341–C active against scab and mites. Although CR 305 controlled scab, it caused some fruit injury. Trials with concentrated sprays gave favorable results against apple scab where various sulfurs, 341–C, TAG 331, and ferbam were used. Growers who tried out recommended concentrated spray formulas are reported to have saved up to 40 percent in their pest control costs, or $30 per acre in one season.

The Missouri station found TAG, like Puratized, capable of inactivating scab even after infections got started. Both caused some leaf yellowing and falling but these were considered of little consequence. Adding sulfur to these materials lowered their scab-killing power. The Missouri station also demonstrated that sooty blotch could be supressed by DN–111, lead arsenate, and Arathane.

The New Jersey station found that although the old standard lime-sulfur and Crag 341–C sprays were effective against apple scab, they produced severe injury. Organic mercuries, which effectively and safely eradicate young scab infections on leaves, controlled scab well and permitted longer intervals between sprayings. Under New Jersey conditions the new SR 406 proved to be definitely more protective against scab after fruit setting time than ferbam, CR 305, or wettable sulfur. Apparently SR 406 also works against Brooks spot.

West Virginia station tests indicated that ferbam is less effective than bordeaux against Brooks spot but the reverse was true for "flyspeck" on apples. In both 1948 and 1949 ferbam proved to be most effective against apple sooty blotch when applied in late May although bordeaux was most effective against it when applied in mid-July under West Virginia conditions.

Improved outlook for stone fruit disease control

Orchardists growing peaches, cherries, plums, and other stone fruits have been encouraged by the recent intensified efforts of experiment stations to explore newer materials and methods in order to arrive at a more effective and economical means of dealing with the disease problems that beset them. The following will illustrate some of the work currently under way.

Further Progress Toward Control of Peach Brown Rot.—The 1949 Report (pp. 87–88) discussed peach brown rot and the researches looking toward its control that are being conducted at the Maryland, Illinois, and Delaware stations. Last year the New Jersey station conducted spraying trials with SR 406, a new-type organic fungicide, which reduced the incidence of brown rot to around 1 percent in harvested peaches. In comparison, trees sprayed with the standard sulfur materials had about three times as much infection.

The West Virginia station devised an ice water sprinkler system which precooled the fruit in bushel baskets rapidly enough to drop the fruit temperature about 38° F. in 15 minutes. This was sufficient to check the progress of brown rot. When further perfected, this method is expected to have wide usefulness in reducing loss of good peaches harvested in wet summers.

The Delaware station showed that peaches shipped by refrigerated truck developed less severe brown rot than those shipped without refrigeration and that careful handling and the use of ventilated containers or containers that prevent contact between peaches reduced infection. Dipping the fruit in dilute lime-sulfur, as mentioned in the 1949 Report (p. 88), continued to give good results in cutting down rot infection and was more effective than any chlorine compound tested. Even five sprays of flotation sulfur applied just before harvesting failed to hold down brown rot. In fact, it is now believed that growers can save money by eliminating these applications. On the other hand, flotation sulfur sprays applied at blossoming time, followed by three summer sprays, reduced the rot at harvest from 56 percent for the unsprayed peaches to about 8 percent for fruits sprayed under such a schedule. The blossom sprays were the most effective.

Nematodes Retard Cherry Seedling Growth.—The Oregon station discovered that meadow nematodes brought about abnormally small growth of mazzard cherry seedlings, which are used widely as cherry rootstock material. Soil fumigation with chloropicrin, a practical measure for destroying root-knot nematodes, successfully overcame the mazzard seedling growth failure.

Cherry leaf spot sprays.—In a study of new materials for the control of cherry leaf spot in nursery plantings the Oregon station found Phygon, 1 pound per 100 gallons, highly effective as a spray. Next in effectiveness came Crag 341–C, followed by zineb, ferbam, and Copper-A compound. At the Oklahoma station ferbam was not only effective as a spray for cherry leaf spot control, but it was even more satisfactory than bordeaux. Foliage sprayed with ferbam had a better appearance than that sprayed with other copper materials. The Pennsylvania station has found 20 selected mazzard cherry trees 25 years old that are definitely resistant to the leaf spot disease, which in several seasons has caused all the leaves to be dropped from susceptible trees growing within a few feet of them. This initial collection of resistant mazzard rootstock material may well be the means of restoring the popularity of this understock which because of its high susceptibility to leaf spot infection has caused heavy losses to nurserymen.

Stone Fruit Virus Research on Nation-Wide Basis.—The growing menace created by the continued spread of virus diseases in cherry, peach, plum, and apricot plantings in all parts of the United States, led the experiment stations and the Department to launch a cooperative research attack on the virus disease problems of the stone fruits in each of the four geographic regions. A project was agreed upon in each region by a technical committee representing the interested experiment stations and cooperating Department research bureaus. Furthermore, an interregional committee was organized. Two interregional subcommittees were appointed to work out the respective problems of developing virus-free rootstocks and of establishing a uniform

series of disease-free types or strains of stone fruits to be distributed to all parts of the country for use in accurately distinguishing between the different virus diseases and between their various strains. This effort is expected to provide reliable means of testing for the presence or absence in seedlings and nursery stock of any strain of virus. Thus it may become possible to eventually eliminate all diseased seedling and nursery stock and diseased sources of seed and budwood.

Some of the specific contributions reported by different experiment stations in the field of stone fruit virus research follow. The Pennsylvania station has contributed information on the different kinds of plants that may carry two widespread sour cherry viruses—the necrotic ring spot virus and the yellows virus—that are believed to cut cherry yields in that State about in half. The same station has also secured information on how to distinguish different strains of the first-named virus both by itself and in combination with the yellows virus on mazzard and mahaleb rootstock seedlings.

The New York State Station has started a planting of virus-free foundation trees of English Morello, Montmorency, mazzard, and mahaleb cherries, each tree tested and retested for freedom from known viruses. In 1949 buds from the disease-free Montmorency were placed in the hands of cooperating nurserymen as starters for disease-free nursery plantings. Other stone fruit varieties free from viruses will be included in the foundation planting as soon as possible. Of 10 varieties of stone fruits compared as testers for the presence of both ring spot and yellows viruses, the Carman peach showed greatest promise.

In the North Central region the Wisconsin, Indiana, Iowa, Michigan, and Missouri stations cooperated in the development of methods for testing (indexing) trees for the presence of viruses. The stations cooperated with nurseries in locating healthy foundation trees and eliminating diseased ones, including rootstock materials, as well as certain varieties of sweet and sour cherries. Some 20 virus-free Montmorency trees located by the Wisconsin station yielded over 5 times as much as similar trees in the same planting that had carried the yellows virus for 6 years. One virus was found to be transferable from stone fruit trees to cucumbers. This offers possibilities for experiments that could not be carried on with woody plants. The use of the cucumber as a speedy indexing plant for stone fruit viruses was being explored.

Fact Gathering on the Nature of Fruit-Tree Viruses.—The Michigan station has observed that red-suture virus of peach can be recognized in the absence of fruit by reduced tree growth and reddened foliage in at least certain varieties. The similarity of the biochemical effects of virus infection and potassium deficiency which may occur in cherries under certain conditions has led to a more intensive study at the Michigan station on the influence of mineral nutrition on viruses.

The Kansas station learned that cherry trees in that State may carry viruses without showing the characteristic symptoms

brought on by them in States farther north. That understock cherries may transmit a virus to some extent through their seeds was first discovered by the Michigan station and confirmed during the year by the Missouri station. The Missouri research also proved that great variation in virulence may occur in different strains of the ring-spot virus and that different varieties of sweet cherries show much dissimilarity in their response to such infections.

First announced by the Iowa station and later confirmed by others is the fact that the hardy and ornamental Manchu or Nanking cherry, *Prunus tomentosa*, is a good host plant for indexing stone fruit viruses. This discovery may have wide practical usefulness in the extensive indexing program necessary to establish and maintain disease-free commercial nursery plantings in all parts of the country.

In the far West much has been done to clarify the confusion resulting from the ability of various stone fruit viruses to attack, singly and in combination, not only peaches and cherries but also plums, apricots, choke cherries, and other wild and cultivated species of stone fruits. Different symptoms are produced not only in each kind of fruit but even in different cultivated varieties of the same species.

The Washington station developed a chemical color test for detecting the presence of different viruses and for determining the presence of reactions brought about by other causes.

In Oregon the search for an insect capable of spreading the "little cherry" or "X" virus in nature met success when cooperative USDA and station research proved that a leafhopper, *Colladonus geminatus*, could transmit the disease. This was confirmed by the Washington station. When practical control methods for the insect are developed, this research may become an important milestone in preventing spread of the virus. The Oregon station has established plantings of virus-free trees for use in experimental work and as foundation stock and has launched a series of orchard experiments on the possible control of the virus-carrying insect. Breeding for resistance to the different stone fruit viruses has also been initiated and a nursery stock certification program developed.

The Utah station isolated a new and virulent strain of virus and named it Dixie rusty mottle. It causes much damage to cherries in the southern part of Utah. The apricot was found to serve as a symptomless carrier of the X virus. Ring spot virus is reported to be the most prevalent cause of degeneration of stone fruit orchards in Utah. Cherry yellows virus effects nearly 100 percent of the trees in many older orchards in the State. Research was continued on the virus strains causing X disease and little cherry with the use of new equipment such as the ultracentrifuge, paper chromatography, and electron microscope.

The Colorado station learned that the Royal variety of apricot does not appear to take the ring pox virus. In a 5-year experiment the Colorado station also found that peach trees inoculated

with mild strains of peach mosaic virus in no case gave rise to severe strains, indicating that it may become possible eventually to give mild inoculations to nursery stock as a protection against severe virus outbreaks.

Citrus and miscellaneous orchard diseases

Keeping Citrus Orchards Healthy.—Root rots play a much more destructive role in citrus crop production than is generally appreciated because their damage is rarely recognizable above ground. The Citrus Experiment Station in California has undertaken to select rootstocks that are most resistant to three fungi commonly found attacking feeder roots in citrus orchards. The possible relationship of thiamine in the bark to the susceptibility of different kinds of rootstocks to the fungus causing gummosis is also being studied. The results of the first tests of rootstock seedlings showed encouraging differences in the amount of damage sustained. One kind of rootstock showed over 85 percent rotted roots, whereas another showed less than 40 percent.

The California station is engaged in research that may alleviate a serious threat to the State's citrus industry from the quick-decline virus disease that appeared in the State a few years ago. In other parts of the world the virus has produced disastrous results. Among the 319 different kinds of insects in California citrus orchards, station scientists found only one, the melon aphid, that was capable of transmitting the quick-decline virus. Research is now under way to determine the natural distribution of this aphid, how it spreads the virus, and how to control it. Rapid methods of diagnosing the disease by microscopic examination have been developed to replace the long and costly transmission test previously used.

Field comparisons made by the Florida station in Argentina and in Florida led to the important conclusion that the South American citrus disease known as "lepra explosiva" is the same as that called scaly bark or nailhead rust by Florida growers. A species of mite has been definitely identified as a carrier of the disease in both countries.

Sprays for Control of Olive Leaf Spot.—Practical control of the foliage-infecting *Cycloconium* fungus which attacks olive trees in California was developed through research by the California station. A single spray application late in the fall before the first wave of leaf infection, proved effective. Two old-time fungicides, lime-sulfur and bordeaux, and a new synthetic fungicide, phenyl mercury triethanol ammonium lactate (Puratized N5E), gave nearly equal control. Where only spring applications were made bordeaux surpassed the other two materials in effectiveness.

Papaya Mosaic Controlled.—The Puerto Rico station discovered that the insect carrier of the southern coast papaya mosaic virus is a plant louse, *Aphis spiraecola,* and developed efficient methods for its control, thereby saving the commercial papaya-growing industry in the island. The station has also

developed a method for testing mosaic virus resistance of papaya seedlings under controlled conditions, and has aided in research for the development of resistant varieties.

New Spout for Tapping Maple Trees Prevents Rot.—The growth and development of the wood-decaying fungus *Valsa leucostomoides* has been established by the Vermont station as the cause of decay around tap holes in sugar maples and of the decay in holes from which sap will not flow. It was found to cause decay for distances of 7½ to 26 inches above and below old tap holes. As a protection against the wood-rotting fungus the Vermont station has introduced a new spout and designed a new pattern for tapping.

Diseases of Small Fruits

Grape diseases controlled with sprays

The Missouri station tested eight different materials or combinations of sprays against black rot of grapes. The older standard bordeaux treatment controlled this disease but produced moderate injury to the fruit. However, satisfactory control was obtained without injury from the newer organic fungicides ferbam and SR 406. Nabam mixed with zinc sulfate gave good results against this disease but caused slight injury. The results were equally good with any of eight different methods of application or types of equipment used, provided proper attention was given to good coverage. For downy mildew control on Concord grapes, nabam, ferbam, and SR 406 proved satisfactory, although bordeaux was best. When sulfur was added, ferbam caused injury.

A 9-year study of the diseases of muscadine grapes at the Georgia station revealed that bitter rot and black rot were the most important. *Macrophoma* ripe rot, although less severe, was another troublesome disease. Certain varieties of the muscadine grapes were found to be practically immune to black rot. No resistance of importance was found against the other two rots. Spraying experiments with bordeaux mixture resulted in a 50-percent increase in yields in 1949, although the 4-year average increase was not quite 30 percent. This research indicates that practices which include the selection of resistant varieties and the use of protective sprays should do much to increase the profitable production of muscadine grapes in Georgia and other southern grape-growing sections.

Breeding overcomes some strawberry diseases

The results of the strawberry-breeding program conducted at many State experiment stations in close cooperation with the Department, is one of the finest examples of man's success in combating plant diseases. The Louisiana station has just brought to a close a project begun over 12 years ago, through which the important strawberry industry of the State was saved from failure. Two types of leaf diseases, leaf spot and scorch, were found to be the cause of the greatest damage. Control by dust and spray fungicides was successfully developed in these tests.

However, the discovery that a high degree of resistance to each disease could be found in certain varieties and strains of strawberry led to the development of a superior variety, Klonmore, adapted to the climate and resistant to both diseases. Klonmore has now replaced the susceptible Klondike variety on about 85 percent or more of the Louisiana strawberry acreage.

Minnesota grows very different strawberry varieties from those grown in the South. Many of them are susceptible to leaf spot and scorch. During 1949 an effort was made to discover varieties adapted to Minnesota that were resistant to these diseases. One Minnesota selection proved resistant to the leaf spot and five out of six Minnesota selections appeared strongly resistant to scorch. Practically all commercial varieties were affected by the leaf spot although a good many were resistant to scorch. A breeding program designed to develop a commercial type for Minnesota that will be resistant to both leaf spot and scorch has been started.

No strawberry disease is giving more widespread concern than the root disease sometimes called "red stele," caused by a soil-borne fungus, *Phytophthora fragariae.* It appeared in this country a few years ago and ever since has been spreading to new strawberry-growing areas. Most of the varieties grown in this country were found to be susceptible. But the Maryland station (coop. USDA) early established resistance in a variety which has become useful in breeding other varieties of commercial value. Through this breeding program strawberry production is again becoming possible in areas where the red stele causal fungus contaminates the soil. Cooperative work continued at the Maryland station has recently shown the existence of a new strain of the parasitic fungus which attacks some strawberries resistant to the original strain of the fungus. Fortunately, certain Scottish introductions have been found that are resistant to the new strain although susceptible to the old one, and breeding for combined resistance to both strains has been started.

The Oregon station (coop. USDA) has contributed much to scientific knowledge of strawberry virus diseases. So widespread are these diseases in the predominant Marshall variety, that the station has started a search for individual, virus-free plants to serve as mother plants for foundation stock by which this important strawberry can be re-established in a healthy condition. Examination of 1,100 individual plants, each from a different certified mother plant, showed that all but 5 carried infection. These 5 promising plants will be kept under observation and will be multiplied if they continue to show freedom from virus diseases.

Controlling blackberry and raspberry diseases

The finding of a previously unrecognized leaf and stem rust was announced by the Washington station. This rust, named *Kuehneola uredinis,* is widespread among blackberries in the western part of that State. It attacks the evergreen blackberry and the Chehalem variety.

The Ohio station, working to determine the range of usefulness of the new method of applying sprays in concentrated form, discovered that anthracnose, probably the most serious disease of raspberries, was controlled at that station by the use of strong liquid lime-sulfur. Instead of the standard dilution and quantity the spray was made six times as concentrated as normal, although only one-sixth of the ordinary number of gallons per acre was applied.

Yellow rust of raspberry causes a drastic reduction in yield and quality of berries resulting from defoliation of the plant. The Oregon station reports that any standard fungicide applied at the proper time will greatly reduce the loss from rust. In dry, hot weather certain plants sprayed with wettable sulfur dropped their foliage although others sprayed with Phygon-XL showed no evidence of spray injury. The value of old-fashioned lime-sulfur was also demonstrated and its availability and cheapness seemed to recommend it above the newer fungicides.

Blueberry disease problems

The New Jersey station (coop. USDA) found that the troublesome virus disease known as blueberry stunt is spread by leafhoppers of a certain type. Research to find control measures for this hopper is now under way.

The Maine station has shown that the application of fungicides greatly aids in bluberry disease control. A dust of arsenate, copper, and lime has proved satisfactory in the past. During 1949, however, three applications of ferbam dust or Tribasic Copper Sulfate gave higher yields than the older formula.

Diseases of Vegetable Crops

Research in vegetable diseases and their control, as carried on by State experiment stations (coop. USDA) constitutes a service from which the consuming public benefits daily. From grower to consumer, the quality of every vegetable, whether eaten fresh, stored under refrigeration, or canned or preserved in the old-fashioned ways, rests on the scientific growing and handling practices developed largely in station research and employed by growers, shippers, and the wholesale and retail markets. Disease control problems require constant watching.

Better disease control in lima beans

The North Carolina station (coop. USDA) has developed several strains of lima beans that show a high degree of resistance to root knot nematodes. Rico 8402, Rico 1216, and 12M were at the top of the list. This station also tested some of the newer synthetic fungicides for protecting lima beans against the seed-borne stem anthracnose disease. Zineb, the best of these fungicides when applied as a spray, increased the yields more than 100 bushels per acre over the 200-bushel yield from unsprayed plots. Dusting was less effective.

The Utah station is studying the resistance of different varieties of lima beans to seed rot. Some of the resistant lines selected showed over 12 times the percentage of successful germination experienced with seed of one of the common commercial varieties susceptible to seed decay.

Progress in control of bean diseases

Fusarium Root Rot Problem Attacked.—Of all the bean strains and varieties tested at the Wyoming station (coop. USDA) for root rot reaction, certain Great Northern types were among the most susceptible. On the other hand, Red Mexican beans were intermediate. Pintos were in general less susceptible, whereas snap bean varieties ranked among the most resistant. Cherokee Wax was at the top of the list in this respect. The precise cause of the root rot condition in Wyoming bean fields was investigated by extensive isolation cultures. The results implicate definitely the well-known, disease-producing group of fungi named *Fusarium*. Also at the Wyoming station 38 different soil and seed treatments were tested for their ability to reduce root rot.

Only two of these treatments resulted in good germination and, in addition, controlled root rot to a considerable degree. Zineb was effective as a seed treatment and, when phosphate fertilizer was added to it, as a soil treatment. The other effective method consisted of dusting with 7 percent copper sulfate and 93 percent sulfur applied to the soil. Regulated, 24-hour heat treatment of seed to insure elimination of bean blight was worked out. It killed bacterial blight and wilt germs which are carried in the seed and did not cause any reduction in germination. Trials with chemicals for preventing the spread of halo blight and common blight on bean foliage showed that dusts containing copper and sulfur were effective. The Wyoming station also tested some 300 varieties and lines of beans by artificially inoculating them with the disease organisms. Over 15 percent of the tested varieties showed considerable resistance to bacterial wilt. Two varieties, Red Valentine and Great Northern Striped Pod, showed no wilt. Nearly 900 different collections of beans were also tested for resistance to bacterial blight. A substantial proportion of these proved to be resistant.

New Measures Against Bacterial Bean Diseases.—The Wyoming station program has also included seed-treatment tests, trials with plant protective materials, and search for resistance to the soil-borne halo blight, common blight, and bacterial wilt diseases. The tests indicated that streptomycin may be effective in the treatment of bean seed contaminated with blight bacteria.

White Mold Control on Beans with Dusts and Sprays.—One of the most baffling of the plant diseases occurring on a wide range of crops over the length and breadth of this continent is the white mold caused by the soil- and air-borne fungus, *Sclerotinia sclerotiorum*. A relatively new organic fungicide, ziram, used by the Oregon station (coop. USDA) in trials, as a dust, or

as a spray in combination with sulfur, proved effective in reducing white mold infections on pole beans. The Wyoming station found dusts of copper-sulfate plus sulfur or Ceresan M plus sulfur (10–90) capable of reducing white mold infection 50 to 75 percent in irrigated crops of dry beans. The Wyoming scientists also dusted with various preparations the soil surface along which the white mold creeps. Thiram and zineb proved to be best for this purpose.

Bean Mosaic Virus Resistant Varieties.—Very common in the Crystal Springs area of Mississippi is a virus disease that causes distortion and pod mottling, like bean mosaic Virus 4 and Virus 4a. Station research showed that the symptoms of this disease differ on different bean varieties. Three out of 19 varieties reported showed no infection: Woods Prolific Lima, Henderson Bush Lima, and Florida Belle. These disease-resistant varieties may provide one answer to the problem of the growers.

Research on tomato disease control

Tomato growing for the processing industry and for fresh consumption extends from the Atlantic to the Pacific and from Canada to the Gulf of Mexico. This vitamin-rich truck crop exceeds in value any other garden vegetable. Because the tomato crop is subject to attack by many infectious diseases several experiment stations are devoting major efforts toward solving the disease problems. In many areas continued profitable production of tomatoes is attributable largely to research in developing practical disease-control measures and to the constant watchfulness of experiment station workers in countering new disease problems as these arise.

Chemical Protectants for Tomatoes.—Perhaps the most important diseases of tomato that can be controlled by chemical protectants are early and late blight, anthracnose, leafmold, septoria leaf spot, and gray leaf spot. These occur in differing degrees in different seasons and in different climatic areas. Fourteen of the experiment stations investigating various protective measures against these diseases have cooperatively reported their 1949 season's results. These seem to point to the general conclusion, based on about 5 years of experimentation with various combinations of new spray and dust materials, that in many areas good protection from such foliage and fruit diseases may be expected at minimum cost if tomato growers will follow their station's recommendations in making applications of dithiocarbamates which are alternated with copper fungicides. Excellent control has been the rule with such combinations as ziram alternating with bordeaux mixture and zineb alternating with fixed coppers such as the basic copper sulfates.

For individual diseases some of these materials have been found better than others. The North Carolina station, for example, recently reported that Tribasic Copper Sulfate was better than any other spray for late blight control. This spray appeared also to control leafmold better than any other material tested.

Septoria leaf spot is a major foliage disease on tomatoes in South Dakota. There the experiment station found zineb spray so effective that the yields of plots sprayed with this material were raised from 5 to 7.6 tons per acre. The Maryland station found that spraying with zineb and fixed copper alternately gave about 25 percent more marketable fruit, yielding a 21-percent more cannable product than unsprayed tomatoes.

Gray leaf spot is troublesome on tomatoes in subtropical areas. The Florida station learned that zineb, which contains zinc, and a new compound of the same type but with magnesium instead of zinc, would give safe and effective protection against gray leaf spot. The same station also reports that some of the newer fungicides will reduce the infection of bacterial spot on the fruit, a disease not common in most other tomato-growing areas. Best of all the materials tested by the Florida station was a copper-containing dithiocarbamate. Next in effectiveness were SR 406 and Phygon-XL alternated with zineb.

In Tennessee a fungus related to the late blight, causing what is known as buckeye rot on the fruit, was controlled successfully with fixed copper compounds with an adhesive added. Since this fungus lives in the soil, the soil as well as the plants were sprayed. Dusting was by no means as effective, in this instance, as spraying.

In addition to zineb and ziram, a new experimental spray material has been found promising in Illinois and Ohio station experiments for the control of tomato anthracnose. In this new substance manganese replaces the zinc of the zineb molecule. The Illinois station has also investigated the reasons why zinc-containing dithiocarbamate sprays sometimes seem to cause increased yields in the absence of disease infections. The research was done in the greenhouse with nutrient solutions supplied to the tomato plants. Where zinc was not supplied to the solution the plants developed deficiency symptoms which disappeared when the leaves were sprayed with the zinc-containing fungicide zineb. The plants apparently were getting the zinc needed for their normal life processes out of the spray. This observation has led to investigations to determine whether double benefit may sometimes be secured by using as a fungicide a chemical that will not only act against infection, but in cases where a mineral deficiency exists in the soil, will strengthen the plants by supplying the deficient element such as zinc, copper, magnesium, or manganese.

The Ohio station, experimenting with sprays applied at four times the usual strength but with one-fourth the usual gallonage per acre, secured evidence that zinc dithiocarbamate sprays applied in this way on tomatoes come close to giving as good control of early blight and anthracnose as the standard sprays. Such concentrated sprays are usually applied with an air blast rather than by subjecting the liquid itself to high pressure. The Ohio station, however, used low pressure (80 pounds) without any air blast but applied the spray with a special nozzle.

Internal Browning of Tomatoes.—The New Jersey station has had a new tomato disease under observation since 1946. The disease, called internal browning, causes a brown corky tissue inside the fruit, especially in that part of the fruit nearest the stem. As much as 50 percent of the fruit in some fields has been rendered worthless. The station, in cooperation with the Rockefeller Institute, has established that the disease is neither a weakness of any specific variety of tomato nor caused by nutritional factors. Instead, it results from infection with unusually severe strains of tobacco mosaic virus. These virus strains were also found to occur in some species of plantain weed, and in several outbreaks the infection was traced to proximity of the tomatoes to plantain-infested fields or to plantain growing near the coldframes in which the tomato seedlings were grown. Practical control was achieved when fields and coldframes were located at some distance from diseased patches of plantain.

Cabbage disease control measures

Hot Water Kills Black Blight Fungus.—One of the advantages enjoyed by the western Washington cabbage seed growing area is freedom from such seed-borne diseases as black leg, black rot, and yellows. The climate has proved favorable at times, however, for a foliage disease known as black blight, caused by the fungus *Mycosphaerella brassicicola*. The Western Washington Experiment Station learned that this disease could be carried on or by the seed. The most successful method of destroying the fungus in the seed was found to be hot-water treatment. The seed is kept in water at 113° F. for 20 minutes, not hot enough to affect the germinating quality of the seed. It is subsequently dried and further protected against seed-borne fungi by dusting with thiram.

Early Start Lowers Cost of Downy Mildew Control.—One of the big problems in southern cabbage-growing areas has been the downy mildew disease. It often gets started in the coldframe and may completely prevent a seedling from becoming a normal plant suitable for setting out. The Mississippi station showed that spraying or dusting with some of the newer fungicides, applied once a week beginning as soon as the seedlings are up, saved the trouble of spraying or dusting twice a week, which is necessary where the disease is allowed to get a start before treatments are begun. In the Mississippi trials Spergon, applied as a spray or dust, with an organic sticker added, gave unsurpassed results. A combination of Tribasic Copper Sulphate and zinc sulfate also gave good results, as did the new organic fungicide zineb.

New Combination Treatment Against Club Root.—In many parts of the country the soil-borne *Plasmodiophora* club root disease of cabbage and related crops has greatly interfered with production. Control has been obtained in many cases by use of large amounts of lime. Now the Massachusetts station has announced that adding mercurous chloride and hydrated lime to

the fertilizer used gives better control of club root than either material used alone, or by those organic fungicides that were tested.

ANTHRACNOSE LEAF SPOT CONTROLLED.—A leaf spot, which in North Carolina attacks turnips, radishes, and Chinese cabbages in spring and fall, was found by the State experiment station to be caused by an anthracnose fungus. All 11 turnip varieties tested appeared equally susceptible. Warm weather favored spread of the fungus. In 1948 Chinese cabbage plants sprayed with Spergon showed only one infected leaf in six, as compared with three infected leaves in four for plants unsprayed. Zineb, ferbam, and zerlate also gave good control, although not quite so good as Spergon.

Research on onion diseases

BACTERIA CAUSE SOUR SKIN IN ONIONS.—Until established by a New York (Cornell) station specialist on bacterial diseases of plants, no one knew precisely what was the cause of a disease of onions known as sour skin, which is prevalent in most of the onion-growing sections of New York State. This bacteriologist found that the disease is produced by a hitherto undescribed species of bacterium to which the name *Pseudomonas cepacia* has been given. It kills off the outer fleshy scales of the onion bulbs. Now that the cause is known control measures can be developed.

CHEMICAL PROTECTANTS FOR ONIONS.—The wide range of new fungicides and adjuvants developed in recent years by the chemical industry are being investigated as possible protective measures against the onion downy mildew. In 1949 the Louisiana station got encouraging results with zineb dust with DDT added for insect control. Next in effectiveness was a copper-mineral oil dust applied with DDT.

Colorado station research showed that purple blotch caused by *Alternaria porri* could be controlled by a spray of either zineb or yellow cuprous oxide applied without too much pressure at the rate of 125 gallons per acre. Addition of a material like polyethylene polysulfide latex helped the spray stick to the onion "pipes." A troublesome condition affecting the crop early in its growth and known as brown blotch was found to result from infection by the same fungus that later causes the purple blotch. The two can be controlled in the same way. Neckrot, often a serious cause of loss of onions in storage, can be reduced by fumigation with nitrogen trichloride gas, according to the Colorado station. This treatment does not work well against rots that are in the bases of the onion bulbs at harvesttime.

Watermelon, cucumber, and cantaloup diseases

Some of the new chemicals show promise against downy mildew, the most feared and damaging disease of cucumbers and melons in the East and South. The South Carolina station found zineb a good control, followed in effectiveness by ziram and Tribasic Copper Sulphate. Sprays in general were better than

corresponding dusts. The North Carolina station also reports good results with these materials when used in dust form. The Louisiana station got excellent control of downy mildew with zineb dust. It found promise as well in a new copper-zinc chromate, Crag 658, and a recently developed complex chlorinated sulfur compound, SR 406, although the former did not give good control of anthracnose. The Ohio station confirmed the value of Crag 658 for downy mildew. Moreover another new material tested in Ohio, zinc dimethyl dithiocarbamate cyclohexylamine (Z.A.C.), not only possessed value as a fungicide, but also appeared to repel aphids although some other materials in the dithiocarbamate class seem to encourage aphids.

The Florida station rated zineb dust, or zineb or Tribasic sprays, as highly effective for control of downy mildew on watermelons. Ziram dust also checked the mildew, but unfortunately encouraged the aphid population and increased the damage from that source. Zineb appears useful also on cantaloups for downy mildew control. Its results were about equal to those secured with Tribasic Copper Sulphate in tests conducted by the New Jersey station. In these trials Crag 658 also gave good control and results with another new material, cupric-N-nitroso phenylhydroxylamine (M–294), were promising. Maryland and South Carolina also found zineb and Tribasic valuable against cantaloup downy mildew.

The control of powdery mildew in cantaloups is difficult, since most of the fungicides commonly used on other plants are either injurious to this crop or do not give adequate control. This disease once threatened to wipe out the important cantaloup-growing enterprise in several areas. Experiments conducted in the spring of 1950 by the Lower Rio Grande Valley experiment station in Texas showed that a new fungicide, Karathane (dinitro capryl phenyl crotonate), was strikingly effective in checking the disease without injuring the plants.

Warding off lettuce diseases

In Maine the late crop of lettuce is severely affected with the virus disease known as yellows, which is spread by means of the six-spotted leafhopper, *Macrosteles divisus*. The Maine station used DDT against the leafhoppers and thereby prevented serious development of yellows. Dusting with DDT was discontinued when the lettuce heads began to form in order to avoid the problem of DDT residue.

The soil-borne fungi *Rhizoctonia* and *Pythium* are generally associated with damping-off of lettuce seedlings. The North Carolina station studied 59 different strains and species of *Pythium* and found that not all of them caused seedling damage. About half of them, however, caused root rot which stunted the plants. Some caused death before the seedlings got above ground, whereas one caused death after the seedlings emerged. Various chemicals were tried as a means of preventing damping-off in the plant bed. Effective control was obtained where the seed was

treated with Spergon or red cuprous oxide and the soil was drenched after planting with ferbam or thiram. Where drenches with mercury or copper were tried the plants were injured.

In some parts of the country, lettuce is badly affected by downy mildew. The California station found zineb spray to be highly effective. It reduced infections to one-sixteenth of the number counted in unsprayed plots.

Spinach, pepper, and celery diseases

The newer types of spray materials and dust fungicides are being tested in an effort to find better methods of controlling spinach, pepper, and celery diseases.

Spinach Protection from Downy Mildew.—In experiments to determine methods of preventing downy mildew of spinach, the California station found that zineb was the most effective of six spray materials tested and of three dusts the one containing Spergon and sulfur proved most satisfactory. The Washington station also found zineb and Spergon effective as sprays and Spergon as a dust.

Of importance in connection with the final choice of material in certain areas may be the finding of the Texas station that dithiocarbamates, such as zineb, may greatly increase the population of aphids on spinach through their ability to check parasitic fungi that kill these insects.

A Difficult Virus Problem of Spinach.—Cucumber virus 1 has caused enormous damage in some spinach-growing areas. Spinach varieties have been developed that are resistant to some strains of this virus. Other strains exist, however, among them strain D, which the Arkansas station found capable of attacking all the previously developed resistant varieties tested under a wide range of temperatures, whereas other strains were able to attack resistant varieties only when the temperature went above 80° F.

Pepper Blight and Rot Control.—The Mississippi station found that spraying peppers with either copper-containing sprays or with zineb will control cercospora blight. Sprayed plots of pepper gave average marketable yields of nearly $160 an acre, whereas plots not sprayed yielded only $45 worth. Copper dusts also were effective against blight but not quite equal in effectiveness to sprays. The Maryland station found zineb and copper sprays effective in reducing rot of peppers.

Pod Mold of Chili Pepper.—One cause for the lack of market demand for dry chili peppers is the presence of molds that grow inside the pepper pods during the drying process. These molds ordinarily cannot be detected until the crop has reached the market centers. The New Mexico station found that most of the mold development takes place in peppers that are harvested and dried after frost has come. The action of frost causes the pod walls to pull away from their attachment to the seed-carrying structure, which leaves a space for air-borne mold spores to

enter. Considerable improvement in quality is expected to result from the harvesting and drying of pods as far as possible before frost.

Improved Control of Celery Blights.—The Oregon Experiment Station has conducted experiments on the control of celery septoria blight. The effectiveness and economy of the standard spraying and dusting methods are being increased by the use of newer fungicidal materials. Ziram and Tribasic Copper Sulphate gave almost perfect control in these tests whether applied as sprays or dusts. Phygon-XL was effective against the blight but caused off-color and stunting of the plants. Actidione gave poor control, whereas zineb gave good control but caused some yellowing of the plants.

For cercospora blight of celery the Michigan station found a dust combining 6 percent zineb and sulfur at the top of the various materials tested. The Ohio station found a ziram spray the most satisfactory of the dithiocarbamate materials tested against this disease in respect to both control and yield benefits.

Source of Celery Virus Survival Found.—The Utah station discovered that celery plants living over winter may be the main source from which celery western mosaic disease gets its start each season, causing losses that have been known to range up to $1,000 per acre. The Utah (coop. USDA) experiments showed that celery plants left in the field from the previous season and containing active virus were still alive in April 1949. Living aphids were also present on such overwintered plants, ready to transmit the mosaic to the new crop in nearby seedling beds. Careful destruction of all celery plants after harvest, therefore, may eliminate the major source from which the disease spreads.

Research on Fungicides

The preceding sections of this report show that the experiment stations are emphasizing experiments on the relative merits and specific ability of the newer fungicides to control serious plant diseases under different climatic and agricultural conditions in all parts of the United States. The number of new chemical compounds that appear promising is increasing. The stations conduct systematic and impartial tests with the more important of these newer materials as they apply to farming in the respective States. Without the help of this evaluation, farmers would be at a loss to know what to expect of the new types of sprays, dusts, seed-treating compounds, soil fumigants, and other chemicals under their local conditions.

In 1949 tests conducted with 215 different fungicides used on 55 different kinds of cultivated plants were reported cooperatively by research workers at 41 State experiment stations, the United States Department of Agriculture, and by 6 Canadian government research stations. The reports make it evident that research is opening the door to promising methods of plant disease control. Several new types of synthetic chemical compounds shown to have outstanding fungicidal properties have the addi-

tional advantage that they do not injure or retard the plant. Progress is definitely being made in plant chemotherapy although activity in this field is still in a preliminary experimental status. Antibiotics are being discovered which have apparent killing power against certain fungi, bacteria, and viruses that attack plants. New soil fumigants are making their appearance that promise to suppress many soil-borne parasites without too high cost. Altogether, there were steady and encouraging advances in this field during the year.

In view of the fact that little or nothing is known as yet regarding the poisonous nature of a number of the newer materials for either man or livestock, a number of experiment stations are participating in experiments to determine the toxicity of various fungicides. Meanwhile, it is manifestly important that experiment station personnel, when using experimental materials, carefully read labels on each container and observe every possible precaution to protect themselves against the possibility of poisoning. Until the harmlessness of a compound to human beings is established, every effort should be made to prevent its contact with skin, lungs, mouth, or stomach and to avoid contamination of food or feed by it.

INSECT CONTROL

It is the job of the economic entomologists at State experiment stations and in the Department of Agriculture to gather information on all economic insects, to learn how their habits may affect plants, crops, and livestock in many areas, and to develop ways in which the harmful insects may be destroyed and beneficial insects increased.

Extensive station research in the past year has demonstrated a wide variety of uses for the newer insecticides developed and now being offered by the chemical industry. With these, insect pests, including many attacking hay and grain for which insecticidal control was formerly too expensive, can now be controlled. Insect pests of fruit can be controlled better, at less expense, and with less injury to the trees. Vegetable insects can be controlled more effectively and, under certain conditions, insect pests can be destroyed in the soil with these newer insecticides. The new insecticides have also made possible more effective control of insects affecting man, livestock, and household commodities.

Insects which have recently appeared in new localities and have threatened to damage crops have been brought under control. Cattle have been protected from grub damage. Research on methods to be followed in forecasting the need for and improving the timing of insecticide applications has been well worth while. Fundamental studies have been made of the physiological process that makes flies resistant to DDT.

Improved pollination of alfalfa blooms and marked increases in alfalfa seed yield have resulted when insect pests were controlled with insecticides and the number of bee colonies was increased. When applied by airplane in the same manner as an

insecticide, an insect virus can be artificially distributed for the purpose of causing a disease epidemic that will control alfalfa caterpillars.

Many studies of the life history and habits of insects, of major importance in insect control, are under way at experiment stations. Some fundamental studies on the life processes and structure of insects, including research on the hard, horny cuticle which encases many species, are shedding new light on the nature of insects, the first step in obtaining effective control.

Caution in handling and applying insecticides to avoid injury is emphasized. It is known that some insecticides are highly toxic and rapid in their action. Others, accumulative in the body, may build up to a toxic level from repeated exposures. Residues on plant and animal products used as human foods and feed for livestock and poultry should be avoided or minimized. All insecticides should be applied as sparingly as is consistent with adequate insect control and unnecessarily heavy applications should always be avoided.

The following examples are a few illustrating recent progress in entomological research at State experiment stations.

Insecticides Aid Crop Production

The advances in insect control made through recent entomological research illustrate the rapid pace with which farm science is moving forward. The practical use of the newer insecticides includes more than applying dusts and sprays. Knowledge of the scientific principles involved is required. In many instances treatment of crops against insects has become a specialty and is conducted on a custom basis. This work requires considerable skill. Where properly employed, however, the utilization of the newer insecticides and of the best methods of applying them should aid in the large-scale economical production of a great variety of farm crops.

Insecticide sprays and dusts profitable on cotton

In experiments by the Texas station on river-bottom soil, the cotton which received early applications of insecticides set an earlier crop but the final yields on these plots did not differ greatly from those on plots treated later in the season. However, in one instance the yields were slightly increased by the early application of insecticides to control thrips. In comparisons of several insecticides applied as sprays or dusts special calcium arsenates (lime-free) were as effective as the organic insecticides for boll weevil control. Toxaphene and toxaphene-DDT emulsion applied at a low pressure and volume per acre were as effective as toxaphene-sulfur dust for boll weevil control. Increases in yields ranging from 543 to 1,185 pounds of seed cotton per acre were produced as a result of 7 to 8 applications of insecticides applied as either sprays or dusts, and profits that ranged from $50 to $125 per acre under conditions of heavy boll weevil and bollworm infestations.

In insecticide tests on cotton, the Georgia station found that good results were obtained with calcium arsenate in alternate applications with 3-percent gamma isomer benzene hexachloride, 5-percent DDT, and 40-percent sulfur. Another material offering much promise was a low-lime calcium arsenate plus 1-percent parathion. Outstanding results were obtained with an organic concentrate emulsion containing toxaphene and DDT applied with a tractor-mounted 6-row low-gallonage sprayer. In two tests spraying increased the yield of seed cotton 1,015 and 1,398 pounds per acre, respectively, over untreated check plots. In general, yields were in direct proportion to the number of insecticide applications made.

The Alabama station showed that the boll weevil population was extremely high throughout the 1949 season. Under this condition gains in cotton yield resulting from insect control were high in all experiments, ranging from 766 to 1,243 pounds of seed cotton per acre. The most effective insecticides in controlling insects and increasing yields were: (1) 3-percent gamma BHC-5-percent DDT dust, (2) 20-percent toxaphene dust, (3) calcium arsenate alternated with BHC-DDT (3-5) dust, or with calcium arsenate and 2-percent nicotine, and (4) low-gallonage (2 to 6 gallons per acre) of emulsifiable concentrates of toxaphene or toxaphene and DDT.

Cotton insect damage in Alabama during 1949 was estimated at 50 million dollars. The major part of insect damage to cotton could be prevented by the general application of the findings of the Alabama station. Net profits of $52 to $77 per acre resulted from the best control methods tested experimentally in 1949. Similar results could be obtained by farmers on many thousands of acres of cotton in Alabama during a season of boll weevil abundance.

Greenbug controlled on grain

A successful method of spraying wheatfields by airplane to protect growing wheat against the destructive grain aphids (greenbugs) was developed by the North Dakota station (coop. USDA). The chemical control procedure developed by the station protected 40,000 acres in the State in 1949, saving wheat at the probable average rate of 5 bushels per acre. The method was later used in spraying up to 500,000 acres of greenbug-infested cereal crops in the Plains region, including 400,000 acres of winter wheat sprayed early in 1950.

Before the discovery of the newer and more potent insecticides, it was generally agreed that the cost of treating grain crops with insecticides was too high to be profitable. Also, before the airplane became generally available for applying insecticides, it was considered impractical to maintain sufficient ground equipment to cover all the areas involved in a greenbug outbreak in the short time between the start of the outbreak and the time when serious damage had been done. Now, however, in addition to airplanes, low-gallonage ground equipment originally developed to apply

herbicides is available in some areas and can be used effectively in greenbug control. Research on new insecticides and new methods of applying them have made possible substantial reduction in greenbug damage to grain.

Research with insecticides on greenbug control on small grains by the Oklahoma station (coop. USDA) resulted in the treatment of 100,000 acres in Oklahoma in 1949. Either dust or spray applications of 0.2 pound of insecticide per acre gave good control. Although insecticides are an excellent control measure for the time being, it may be that in the long run resistant varieties will provide the best solution. Results to date at the Oklahoma station indicate that resistance to greenbugs in barley is an inherited characteristic, and preliminary greenhouse tests with wheat indicate that greenbug resistance may be increased by field selection.

Field control of fire ants

For over 20 years, the Gulf Coast area of Alabama has been harassed by the imported fire ant. It is an economically important pest because it attacks germinating seeds and young tender plants and builds unsightly mounds which may damage machinery such as mowers and combines. Its painful sting from which it derives the "fire" in its name makes it an annoying pest.

In control experiments the Alabama station found that frequently the only practical treatment consists of applying insecticides to the mound or anthill itself. Chlordane either as a 10-percent dust (2 ounces per hill) or as a 2½-percent emulsion spray (½ pint per hill) was almost 100 percent effective when the mounds were broken down by hand raking and the insecticide was mixed with the soil. Other insecticides that gave good results consisted of 20-percent toxaphene dust, 2½-percent aldrin dust, 3-percent gamma BHC and 5 percent DDT (cotton dust), and a 1-percent dieldrin dust. Where chlordane is available, it is recommended at present for mound treatment.

The results of field tests on large areas indicated that over 90-percent control was obtained when 20 pounds of 10-percent chlordane dust were applied either before or after disking of the soil. The insecticide continues to kill for weeks after the treatment. Chlordane dust, when applied without disking, was much less effective. However, chlordane sprays applied at the rate of 2 to 4 pounds of technical chlordane per acre showed promise as a control for fire ants without disking. From February to May should be the best time to treat either hills or larger areas, since the winged forms swarm from the nests during the spring and early summer to establish new colonies.

Insecticides in "setting water" protect tobacco plants

Tobacco growers in Kentucky often suffer severe financial losses from tobacco wireworm attacks when the plants are set in the field. Almost half (43 percent) of the untreated plants in the Kentucky station experiments were damaged by wireworms. Damage of this kind often requires an expensive resetting job to replace the plants injured by wireworms.

Station research has shown that the use of insecticides in setting water is a practical means of controlling wireworm injury on newly set plants. In preliminary tests, parathion, chlordane, aldrin, and BHC, when added to the setting water at low dosages, reduced the number of plants injured from 11 to 21 percent as compared with 43 percent for the untreated tobacco plants. These results are encouraging but they indicate that somewhat larger amounts of the insecticides are needed for adequate control.

Spittlebug control boosts hay yields

Research at the Ohio station on the control of the meadow spittlebug in mixed clover and alfalfa has demonstrated the large amount of damage done by these insects in the field to the yield and nutritive value of hay. Control measures on small experimental plots and in large-scale field tests resulted in from 20- to 55-percent increases in first-cutting hay yields in 1949. Some increase in carotenoid and protein content also resulted.

Benzene hexachloride at the rate of 0.2 pound of gamma isomer per acre, applied soon after hatching of the eggs (about 5 weeks before harvest), has been recommended for the control of spittlebugs. Where such applications are made, the value of an average yield of hay may be expected to increase about 20 percent over hay acreage not treated.

Peach insect control improved

The plum curculio has damaged 50 percent of the peach crop in North Carolina in some seasons. Scale insects and peach tree borers also attack and weaken peach trees, resulting in the death of many trees each year. To reduce these losses the North Carolina station has investigated the use of the newer insecticides for the control of insect pests of peaches. In this work parathion gave outstanding results for the control of plum curculio in both laboratory and orchard and did not have an adverse effect on the flavor of peaches. It also gave fair control of San Jose scale. If the summer sprays used for the control of plum curculio will control the San Jose scale, it will be possible to eliminate the use of dormant sprays on peach trees except where white peach scale is present. In orchards in which white peach scale is present the infested trees could be marked for individual treatment with dormant sprays. This technique would save valuable labor and materials.

In field tests of the value of summer sprays for control of the peach tree borer, applications of DDT and parathion or DDT plus parathion reduced the population of borers to an average of one-half to one borer per tree. The use of summer sprays keeps the borers from causing damage to the tree, and it is anticipated that this will aid in increasing the life of the tree.

Assuming that parathion continues to give as good control as it has already in these trials, it will be possible for growers to produce fruit which is free of worm damage and higher in qual-

ity. However, the station points out: *"READ AND OBSERVE PRECAUTIONS CONCERNING PARATHION! It will kill people as well as curculio."*

Cherry maggot control

The Washington station has developed a highly effective bait trap to determine the relative abundance and dates of emergence of the cherry fruit fly. Ammonium carbonate is used as the bait. Spray schedules synchronized with the emergence of the flies, as indicated by the trap, made it possible for Yakima Valley growers to ship 978 carloads of cherries in 1949, none of which were condemned because of fruit fly damage.

The Pennsylvania station has developed an effective means of protecting cherry growers from losses resulting from cherry maggots. Canners will not buy cherries in which more than 0.5 percent are infested with cherry fruit fly maggots. Since all wormy cherries must be removed from a lot before processing, a higher percentage is considered too costly to handle at the cannery. Rigid control of fruit flies in the orchard is, therefore, necessary. In experiments made near Lake Erie, lead arsenate has been found to be satisfactory for the control of the cherry fruit fly. Parathion was just as effective as the standard lead arsenate treatment and its residue on the harvested fruit did not appear to be a problem of major importance. Parathion evidently is toxic to adult flies and tests indicate that it will kill the immature stages of the fruit flies in the fruit.

PARATHION IS VERY POISONOUS AND MUST BE HANDLED WITH GREAT CAUTION.

Insect outbreak threat averted in berry plantings

Berry growers who produce over $4,000,000 worth of raspberries and blackberries in the rich soils near Portland, Oreg., were alarmed when an insect known as the orange tortrix was reported in the area in 1947. In 1948, Oregon station entomologists mapped out areas of original infestation, and the rate and direction in which the tortrix was spreading. As a result of this survey, growers were able to put control measures into operation in 1949. Cryolite, which is used to control the attacks of this pest on oranges, cannot be used safely on berries, and station workers therefore recommended the use of TDE (DDD). Spring applications of this insecticide drastically reduced the insect population, and thus averted a serious threat to the future of the berry industry.

Insecticides improve yield of tomatoes

The Delaware station sprayed tomatoes three times with DDT and methoxychlor at biweekly intervals prior to harvest and obtained effective control of insects that were damaging the fruit at the Georgetown Field Station. At this location the tomato fruitworm caused about half the injuries. Although the yield was severely restricted by drought, plots sprayed with either

insecticide produced 1.4 tons more per acre than untreated plots. This increase was equal to about $42 per acre, whereas the estimated cost of the three spray applications was $15 to $18 per acre. In a similar experiment at Newark, where insects destructive to this crop were scarce, no significant differences were found between treated and untreated plots.

Better control of destructive cucurbit insects

On the basis of three seasons' work on squash and cucumber crops the Tennessee station is able to recommend 1-percent lindane for the control of all insects attacking these crops. Cryolite is effective for beetles and the pickleworm but does not stop aphids or squash bugs. The use of lindane has resulted in increased yields as well as better control. Formerly it was not unusual to have had at least a 75-percent loss of cucurbit crops. Late crops can now be grown in Tennessee, which usually was not possible before.

Tests during the summer of 1949 by the Kentucky station showed that the striped cucumber beetle and the striped flea beetle can be effectively controlled on cucumbers. Excellent control was obtained with 3-percent purified DDT and 5-percent methoxychlor when used as dusts at 7- to 10-day intervals. Other insecticides tested were inferior. Cucumber vines treated with purified DDT and methoxychlor produced 47 and 59 percent more cucumbers, respectively, than were produced in plots treated with the standard calcium arsenate treatment.

The Georgia station reports experiments in 1949 with a number of insecticides for control of the pickleworm on squash, cantaloup, and cucumber, in search of a material more effective than the presently recommended cryolite and 2-percent DDT. The insecticides were applied as dusts at 7- and 14-day intervals at the beginning of the blooming stage. Promising results were obtained with 0.5- and 1-percent parathion and 5-percent purified DDT. These materials gave higher yields of worm-free fruit than cryolite and 2-percent DDT. No plant injury was noted. Results of the squash tests indicate that the time interval of 7 days between applications may have to be reduced in order to obtain maximum production of worm-free fruit.

Garden centipede control increases crop yield

Excellent control of garden centipedes has been obtained by the Oregon station by treating the soil with chlorinated propane-propylene, used at the rate of 30 to 35 gallons per acre. Control from one application has endured for 3 years and may last even longer. The success of this treatment depends on timing, on the preconditioning of the soil, on efficiency of application, and on how well control measures can be made to fit into established farm practices. Growers have found that despite the high cost of the chlorinated propane-propylene treatment it has proved profitable in practice on high-income crops.

Soil fumigation does not meet the needs of back-yard growers or growers who produce relatively low-income crops. Cultural practices such as rotary tillage, planting of the seed when the soil is somewhat dry, or the planting of crops which are not seriously damaged by garden centipedes, may be followed by growers who find it necessary to live with this pest.

Although there is a definite need for residual soil insecticides which will control garden centipedes, more information about the safety of these chemicals is needed before control recommendations can be made.

One entire farm (30 acres) has now been treated with chlorinated propane-propylene for garden centipede control. Control in some plots has lasted for a 3-year period. If the treatment has had any harmful effect on soil micro-organisms, it has apparently not been of a permanent nature. Root growth on pole beans in treated soil has been remarkable and vine growth has been equally good. Missing or weakened hills have been practically nonexistent. Yields of pole beans have been brought up to normal and have increased approximately 4 tons of graded beans per acre.

Aerosols control greenhouse pests

Research at the Ohio station has shown that organic phosphate aerosols are effective in controlling red spider mites. These mites, if unchecked, would severely damage the valuable crops of vegetables and ornamentals grown extensively in greenhouses in that State. Of the three organic phosphate aerosols tested extensively in control of mites on vegetables 5-percent tetraethyl dithiopyrophosphate (USDA Formula No. 178), used in 24 tests, produced an average mite mortality of 95 percent and caused no foliage injury. Inasmuch as this aerosol leaves no residue after 6 hours it may be used during the picking season. The 5-percent hexaethyl tetraphosphate aerosol which has also been tested frequently is slightly less effective than Formula No. 178 but is more readily available. The 10-percent parathion aerosol proved most effective in control of mites and was effective also against most of the insects that attack hothouse vegetables. The average mortality of red spider in 6 tests was 99.5 percent. Seedling tomato plants used in each test were not injured. Inasmuch as this aerosol leaves a residue for several days it can be used on greenhouse vegetables when the plants are small, but not during the picking season.

All three of the organic phosphates mentioned are very poisonous and the proper precautions must be followed exactly to avoid fatal accidents.

The Ohio station points out that aerosols in 5-pound steel cylinders are rapidly replacing water-base sprays for the control of mites on greenhouse vegetables. With an aerosol one man can treat an acre in 30 minutes and control mites more effectively than was possible with a sprayer which required the labor of three men for 4 to 6 hours. The parathion aerosol, which is being used

before the picking season, not only controls mites almost completely but also prevents damage by most of the troublesome insects.

The Pennsylvania station tested about 40 additional varieties of greenhouse plants for tolerance to parathion aerosol and found that none showed unfavorable reaction to the aerosol. From their research on greenhouse pests the station concluded that parathion aerosol still appears to be the best treatment against the red spider mites, but that it is most satisfactory when used during the warmer months and when other aerosols are used during the darker months to avoid plant injury. Studies on dithiotetraethyl pyrophosphate aerosol showed that, used at 3-day intervals for four or five consecutive treatments, it would usually, but not always, control infestation of the so-called "resistant" red spider mite which parathion had failed to control.

How flies may resist DDT

A study of biochemical differences between certain DDT-resistant and nonresistant houseflies made by the California station has shown that disappearance of absorbed DDT within the body of the insect is characteristic of the former. It is not a matter of failure of the DDT to penetrate, as many times as much DDT enters the resistant fly.

Action of insecticides on insects

Among several compounds which increase the toxic action of pyrethrum tested by the California station, only one strongly promotes the toxic action of DDT. It appears to do so by decreasing the rate of inactivation of DDT within the insect.

Compounds closely akin to several vitamins and amino acids essential to nutrition of insects have given marked inhibition of growth and other toxic effects when fed to German cockroaches. These effects are caused by the presence of these competitive inhibitors of essential nutrients.

Studies of the effect of numerous organic phosphate compounds on the activity of the enzyme cholinesterase have disclosed that the highly toxic compounds lower the activity of this enzyme by 90 percent or more, and that the nontoxic compounds have no effect on the enzyme. The close correlation between reduction to about one-third normal activity of the enzyme and the onset of toxic symptoms and between reduction to near zero activity and death show that inactivation of the enzyme could be the chief mode of producing the toxic action of these insecticides.

Fewer bugs, more bees, more alfalfa seed

One of the important causes of decline in alfalfa seed yields has been the increasing prevalence and severity of damage from the feeding of *Lygus* bugs. The Utah station (coop. USDA) studied the effects of different numbers of *Lygus* bugs in alfalfa fields by counting from time to time during the season the bugs caught in a single sweep of an insect net at different points in

different fields of alfalfa. The results were striking. In places where about 7 bugs were taken on the average at each sweep of the net, there were only about 12 flowers on each stalk, yielding about 6 seed pods and the total crop of seed per acre was poor, about 53 pounds. On the other hand, in fields where on the average only one bug was caught at a stroke, each alfalfa blossom stalk averaged over 15 blossoms, yielding more than 9 seed pods and a seed crop of something over 270 pounds per acre.

Because Utah growers are controlling these bugs by utilizing experiment station findings on newer insecticides, the yield of alfalfa seed has risen from an average of 102 pounds per acre for an 18-year period before insecticides were used to an average of 210 pounds for 1949. Further experiments have shown that sprays are better than dusts for *Lygus* bug control and that toxaphene promises to be effective against various alfalfa insects during the blooming stage and offers less probability than other insecticides of poisoning the bees, which are needed for pollination.

At its Fort Hays Branch the Kansas station found that insecticides gave effective control of grasshoppers, garden webworms, potato leafhoppers, and *Lygus* bugs that were damaging alfalfa. They also found that a sufficient number of honey bee colonies to provide good crosspollination would increase seed yields where insect pests are controlled. In insect-controlled test plots containing 4 to 6 colonies of honey bees per acre alfalfa yields of 853 to 1,073 pounds of seed per acre were obtained.

In another experiment, in which DDT plus BHC was used when (1) the alfalfa was 4 to 6 inches high, (2) in the prebud stage, and (3) at both times, the double treatment plot gave better control of grasshoppers, garden webworms, and potato leafhoppers than either the early or late treatment and approximately the same control of the tarnished plant bug as the late treatment. The seed yield in the plot treated both times was 30 percent greater than either the early- or the late-treated plots and 116 percent greater than in the check plot.

In general, Kansas growers have learned from this research that the correct application of insecticides to alfalfa will decrease the numbers of leaves lost, increase the number of flowers available for pollination, and if the pollinating insects are abundant, increase the seed yield from 75 pounds per acre (the average for Kansas) to 300 to 500 pounds per acre.

Biologic and Cultural Control

Studies in insect control have shown that in addition to insecticidal methods, cultural methods, biological control, and the development of plants resistant to insects offer considerable possibility in plans for controlling insects.

Alfalfa protected from caterpillar by applied disease virus

The research of the California station has shown that airplanes and ground equipment are effective in spreading the virus disease

that controls the alfalfa caterpillar (*Colias*), a very serious pest of alfalfa in that State. This development follows the previous discovery by the station that epidemics of a polyhedrosis virus disease of the alfalfa caterpillar can be caused by treating the threatened alfalfa crop with virus produced in the laboratory. As insecticide residues on alfalfa may appear in animal products after the crop is fed, a satisfactory nontoxic material that would control this pest would be most useful. As a result of extensive tests, it appears that the virus is harmful only to alfalfa caterpillars.

In general, natural outbreaks of this disease cannot be depended upon to occur early enough and regularly enough to give satisfactory economic control of the caterpillar, and it does not appear likely that such outbreaks of this disease can be consistently induced through cultural practices. Although the virus may be transmitted by a number of mechanical factors including contaminated *Colias* butterflies, insect parasites, carnivorous insects, wind, rain, and irrigation water, natural outbreaks of the disease occur usually only after serious damage to the alfalfa has been caused by a dense population of the pests.

Artificial outbreaks of the disease can be caused by the application of a virus suspension containing 5,000,000 polyhedra per milliliter at the rate of 5 gallons per acre. This dosage appears to be adequate to insure infection of a field population, at least under the conditions usually encountered in the northern San Joaquin Valley.

Large quantities of virus material can be prepared at very little expense and can be preserved for at least 2 years. Cost of the virus application itself is the same as that of an insecticide application, but general use of the virus as a means of practical control of the caterpillar will probably require competent supervision by trained entomologists.

The airplane is a convenient means of treating most fields with a virus suspension. The California station's experiments with aircraft during 1949 are believed to be the first ones in which this method was used to produce an outbreak of disease in a large population of insect pests. Small fields, however, may be more suited to application by ground equipment.

If the method is perfected, it will provide the farmer with another means of controlling insect pests attacking crops of great economic value.

Birds aid in Japanese beetle control

A survey of Japanese beetle grub populations in the fall of 1949 by the Ohio station indicated that spores of the milky disease, used to control the Japanese beetle, may be spread by natural carriers.

In collections of the beetle grubs taken on a golf course near Marietta more than 50 percent of the larvae were infected. No spores of the milky disease had been planted in the Marietta area. Since the nearest plantings were made at North Salem and

Steubenville, about 60 miles away, the probable explanation is that birds were responsible for spreading the spores. Robins particularly were observed in large numbers feeding upon the grubs and other insects in the course. Since most of the infestations in northern Ohio have been treated with the spores of the milky disease, it would be logical to assume that the birds stopped to feed on their southern migration, and that the spores were carried to the Marietta area during the flight southward.

Weevil damage to corn

The Alabama station is attacking the problem of reducing the 12-million-dollar annual loss from stored grain pests by breeding and selecting resistant varieties, and also by the proper use of fumigants and seed protectants.

Varietal resistance studies of corn revealed that rice weevil damage at maturity varied from 2.2 percent on Dixie 18 to 26.1 percent on U. S. 13 at one location, and from 3.4 percent on Dixie 18 to 34.8 percent on Dixie 17 harvested later at another location.

In this connection nine different factors relating to rice weevil damage to corn were studied by the Alabama station with the following interesting results. (1) Good husk cover was very effective in preventing rice weevil damage to corn. Husk cover ratings were compared with the weevil damages found on 20 varieties. (2) Worm holes were also important—ears with no worm holes in the husk showed 14-percent weevil damage, whereas those that had been entered by corn earworm or fall armyworm had 47 percent damage. (3) The earlier corn was planted, the more weevil damage it suffered. (4) A 20-variety comparison showed that the harder the kernel, the less was the weevil damage. Each additional pound of pressure required to penetrate kernels with a $\frac{1}{16}$-inch hollow punch gave a 1-percent decrease in weevil damage. (5) There was no relationship between thickness of the kernel pericarp and weevil damage. (6) Weevil damage was inversely proportional to the number of corn plants per acre, and (7) to the number of days required for corn varieties to mature. (8) There was no significant relationship between irrigation and rice weevil damage, or (9) between phosphorus or potassium fertilization and weevil damage. In one test in which a variety was grown with varying rates of nitrogen, the weevil damage appeared to be worse at the higher rates. By the application of the principles involved in the nine factors listed and by breeding and selecting corn varieties resistant to rice weevil damage, a steady reduction will be made in the estimated heavy loss in the State from this stored grain pest.

Planting date affects corn damage by borers

The date-of-corn-planting research of the Ohio station has shown that stalk breakage from European corn borer damage was cut almost in half by the proper planting date. An experiment involving five commercial hybrids, planted in fourfold replication on four dates in three latitudes of the State, indicated

that under two-generation borer infestation attention to optimum planting dates effected a degree of corn borer control, as evidenced in the percentage of infested stalks, in the numbers of borers per infested stalk, and in an associated reduction in plant injury as measured by stalk breakage. In all locations, plantings made later than May 20 were most heavily infested and showed greatest injury. At Van Wert, dent corn hybrids planted May 25 in a date-of-planting experiment received few borer eggs and showed an autumn population of one borer per stalk and 20 percent of broken stalks. The same hybrids planted June 12 showed a fall population of five second-generation borers per stalk and a breakage of 38.5 percent of the stalks.

In a fall survey of 29 Hancock County dent cornfields, those planted between May 10 and May 14 were more heavily infested than those planted May 15 to May 19. Fields planted May 20 to May 30 were more heavily infested than those of the early period. These and similar observations indicate that dent corn plantings should be timed to avoid extremely early or late dates in order to control corn borers most effectively.

Corn shows resistance to insects

The Kansas hybrid corn K1859, developed by the Kansas station, and recently approved for distribution, showed significantly low corn earworm injury and also low infestation by the corn leaf aphid.

The Minnesota station (coop. USDA) has developed lines of hybrid corn that are resistant to the first brood of the European corn borer. This research offers hope that eventually lines of corn resistant to the second brood of corn borers, which is the one that does the greatest economic damage, may be developed.

In 1949 the Ohio station released three new inbred lines for use in producing hybrid corn. All three are resistant to the first generation of the European corn borer as well as to aphids, leaf blights, and low autumn temperature.

As the loss from European corn borer in 1949 was estimated at 313,819,000 bushels of corn worth $349,635,000 at 1949 prices, even partial resistance of corn to damage from this insect is valuable.

Insects Attacking Poultry and Cattle

Although the major research of entomologists at the State stations was directed toward the protection of crops, poultry and domestic animal pests also received attention, as shown by the following progress in this field.

Effect of mosquitoes on poultry

The Alabama station found that common mosquitoes prefer to feed on chickens. During the season when the mosquito population was highest, hens protected from mosquitoes laid at the rate of 61.5 percent and nonprotected hens at the rate of 56.7 percent. Of the mosquitoes found on poultry farms over 95 percent were southern house mosquitoes. Serological tests showed

that over 95 percent of the mosquitoes collected from chicken houses were positive for chicken blood. The sensitive serological tests necessary to accurately identify the blood of the different animals and birds on which mosquitoes had fed were developed by basic research. When these mosquitoes were allowed free choice of animals, 47 percent fed on chickens, 33 percent on dogs, 13 percent on pigs, and 7 percent on both dogs and pigs.

On all chicken farms studied, the mosquito population was very high in July, again in late September, and reached its peak in October.

Cattle grub control on large area

The South Dakota station (coop. USDA) demonstrated the practicability of controlling cattle grubs on a voluntary community basis. Approximately 15,000 head of cattle in four areas are being treated in the program which was started during the 1947–48 cattle grub season. The largest area is located in Hughes County and contains approximately 9,500 head of cattle on 90 ranch units covering about 300 square miles. Smaller areas are located in 3 other counties. The cattle are treated with rotenone in washes or dusts, or by power sprayers. In each case the rancher specifies the method by which he wishes to treat his cattle and is furnished the required amount of rotenone free of charge.

Cattle grubs are harmful to cattle and aggravating to ranchers. Because of the reactions of the cattle to the ovipositing adults, commonly known as heel flies, handling of cattle during the fly season becomes a difficult task. The presence of grubs under the skin of slaughtered animals necessitates wasteful trimming of carcasses, and the holes eaten through the skin reduce the value of the hides. The presence of these pests in the animal's body may decrease the rate of gain in weight. In dairy stock both the attacks of the flies and the presence of grubs in the body may reduce the production of milk.

After the control program had been in operation for 3 years, the yearlings in the central part of the main area had an average of 15 larvae per head for the season. This represented a reduction of about 85 percent in the number of larvae in these animals as compared with cattle outside the treated area. Near the edges of this area the average increased to 65 grubs per head, whereas outside the area the infestation averaged 89 grubs per head.

Insects Control Weeds

Crop pests are often classified as insects, diseases, and weeds. In the fight against St. Johnswort, the State experiment stations have turned one of these pests against the other to obtain effective weed control.

Beetles control foreign weed on western ranges

The California station (coop. USDA) has been successful in establishing two kinds of beetles which are actively spreading.

These beetles feed on and effectively destroy the troublesome St. Johnswort, which is a pest of certain California grazing areas. This foreign weed is also called Klamath weed, Tipton weed, and by other local names. As it extends north into Oregon range country, where it is equally objectionable and persistent, the Oregon station (coop. USDA and the California station) brought the first two batches of beetles into Oregon and liberated them near Corvallis and Salem in 1947. In 1948 batches were set free in other Oregon locations.

Investigation has disclosed that the beetles were surviving and by 1949 were feeding on the weed although they were not yet numerous enough to hold it in check. Observations in the spring of 1950, after the most severe low temperatures in Oregon history, showed that the beetles had not only survived the rigorous winter but were stripping the plants clean of leaves and causing their eradication in the vicinity of the original colony sites. There is reason to hope that these beetles will eventually be able to hold down the St. Johnswort permanently and at practically no cost other than the expense of the original colonizations.

SOIL SCIENCE AND PLANT PHYSIOLOGY RESEARCH

Since all agriculture stems from the soil, the fields of soil science and plant physiology are intimately associated with progress in plant and crop improvement. In recent years agriculturists have put major emphasis on fundamental research dealing with the nature of soils and their behavior. Studies on soil and water management, soil chemistry, soil physics, soil microbiology, plant nutrition and physiology, and the production and use of fertilizers all touch on various phases of fundamental science. Some of the knowledge now coming out of these researches is providing the tools that place farming on the threshold of a new era as we enter the second half of the century. With these tools, leaders in soil science confidently expect to see in the next 20 years progress that will compare favorably with that of the past 50 years.

A summary of recent progress in soil science and plant nutrition research follows.

Soil Management Practices and Soil Productivity

Many crop-production problems are in one way or another related to the physical status of the soil. Crop yields are limited in nearly all sections of the country by deterioration of the desirable physical qualities of soils. Outstanding advances have been made in the past 15 years in methods of fertilization, seed treatment, the use of better seed of improved varieties, and better methods of disease, insect, and weed control. Average acre yields have either been maintained or increased in most sections of the country. However, the full economic gains from these improved practices are not being attained because of such factors as low water-holding capacity, lack of organic matter, high soil com-

paction, and consequent reduction in soil aeration. The desired level and economy of production cannot be achieved without widespread adoption of improved soil-management practices.

Few of the older field experiments were designed primarily to follow the effects of different rotations and management practices on changes in soil physical properties. Even with the techniques in use today, it is often difficult to correlate these changes with crop yields. Much research is still needed before it will be possible to characterize soil conditions in relation to their effect upon plant growth. Techniques are now being developed by which a more accurate evaluation of changes in soil structure may be made.

Cropping practices have a pronounced effect upon the coherence of individual soil particles to form granules, or aggregates. A new index for characterizing the degree of aggregation of soils has been developed by the Iowa station (coop. USDA). This procedure employs as an index a statistically averaged size of all of the aggregates remaining after wet sieving. This index is called the "mean weight-diameter." It gives a better correlation with crop yields than is possible under the former method of correlation in which the fraction of water-stable aggregates greater than 0.25 or 2.0 millimeters was stated. The index of soil aggregation was twice as great under corn in a corn-oats-meadow rotation (0.59) as under corn grown continuously (0.28) in the nineteenth year of an experiment conducted on Marshall silt loam soil. Aggregation of soils under corn, following 11 years of alfalfa, dropped from 1.03 millimeters in 1942 to 0.78 millimeter in 1944 and decreased gradually each year to 0.43 in 1949. Organic matter in the Iowa experimental plots decreased during the past 7 years in the corn-oats-meadow rotation. Where the organic matter was low, following 11 years of corn (1931–42), no further decrease resulted from 7 years of the 3-year rotation. A sharp decrease in organic matter resulted from growing corn for 7 years, following 11 years of alfalfa. Eleven years of alfalfa increased the amount of organic matter slightly, whereas under bluegrass, organic matter was maintained at its initial level.

Various crop residues and soil micro-organisms were studied at the Wisconsin station in their relation to soil physical properties. When soils were inoculated without crop residues being added, they underwent only slight to moderate changes in degree of aggregation. Inoculation, plus the addition of alfalfa residues, improved the physical condition of the three soils studied. The addition of alfalfa residues alone resulted in less improvement in structure. Inoculation with various mold species in the presence of alfalfa reduced the susceptibility of soils to erosion.

The importance of organic matter in obtaining aggregate stability in soils is further emphasized by findings of the New York (Cornell) station. Observations on the residual effects of manure treatments (made from 1923–47) on Sassafras silt loam soil were continued. Aggregate stability was significantly greater for soils receiving the higher manure applications, and the degree of com-

paction was appreciably less. Heavy wheel traffic on the high manure plots did not increase compaction above that of the low organic matter plots which received no traffic. The organic matter content of these plots ranged from 2.4 to 5.5 percent.

Studies on the effects of different management practices on soil aeration will be facilitated through the use of apparatus developed and perfected by the New York (Cornell) station, for measuring the oxygen diffusion rate of soils in the field. This apparatus was successfully used in characterizing the aeration status of soils in tillage experiments. Equipment was also developed for measuring the percentage of air-filled pores of soil cores. This equipment (air picnometer) has the added advantage that it permits the moisture content of soils to be determined without the delay required for the usual method of oven-drying.

That cultivation may be beneficial for purposes other than weed control, at least in seasons when weather conditions may cause excessive crusting of the soil, is indicated in research at the [Connecticut] Storrs Experiment Station. On randomized plots receiving equal amounts of fertilizer, the regularly cultivated plots averaged 94.6 bushels of corn per acre. Where one cultivation was employed in addition to 2,4–D, the yield was 84.7 bushels per acre. Where the plots were scraped to control weeds, the yield was 80.3 bushels, and where 2,4–D was used alone, the yield dropped to 68.3 bushels. Porosity studies showed that the surface 2 inches of the plots receiving normal cultivation had an appreciably greater amount of desirable pore space than the other cultivated plots, and that the plots treated with 2,4–D had the least.

Experiments at the Idaho station showed that soil aggregates from well-managed plots were 150 to 200 times more stable than those from the continuous-wheat or the wheat-fallow plots. Where the initial permeability rate of soil was high, it remained so, even under long-continued rains, showing that it had high aggregate stability. Under continuous-wheat and wheat-fallow production systems, soil losses were as high as 30 tons per acre. The use of good soil-management practices to maintain structural stability has resulted in very great savings of both soil and water, factors of great significance to the agriculture of the Palouse area. Yields in this area have declined because of the loss of soil and the nutrients it contains. In the Idaho experiments, the loss of nitrogen alone from erosion amounted to as much as $19 per acre per year.

A 2-year rotation of corn, oats, and sweetclover was compared with continuous corn at the Indiana station. The soil in rotation plots had a higher amount of desirable pore space and a much greater degree of aggregate stability. In other studies, soil under bluegrass showed greater aeration, was more porous, and contained a greater number of micro-organisms and a larger amount of organic matter than soil under continuous corn. A method for determining the air porosity of soils through the use of a special (petrographic) microscope was developed.

Effect of rotations on nutrient supply

Experiments with different rotations and fertilizer practices have been conducted by the Missouri station for over 60 years. It is now evident that the use of rotations alone did not maintain the crop-producing capacity of the soil. Failure to add plant nutrients in excess of the quantities removed by leaching, soil fixation, erosion, and by the crop, has resulted in a steady decline in both fertility and crop quality. The average annual per acre removal of nitrogen from the soil by crops amounted to 2 pounds of nitrogen per bushel of corn, 2 pounds per bushel of wheat, 1 pound per bushel of oats, and 20 pounds per ton of timothy hay. On plots receiving barnyard manure, only about 3 pounds of nitrogen were supplied annually to the immediate crop by each ton of manure. Nearly 70 percent of the manure applied went into the organic matter reserves of the soil, from which nitrogen was released at rates comparable to those of humus. After 60 years of cropping to corn, 6 tons of manure being added annually, approximately half of the organic matter in the soil was derived from the manure.

Where limestone was applied in a 2-year rotation of corn, wheat, and sweetclover, the amount of available magnesium in the soil was decreased to a low level. In 1949 plots thus treated produced 8.5 bushels of wheat per acre less than where the soil had not been limed and sweetclover had not been grown. The higher yields of corn and wheat produced in the legume rotation and the fact that a high calcic limestone was used, account for the decrease in available magnesium. In late years both the corn and clover in the Missouri experiments have shown magnesium-deficiency symptoms. In other rotation experiments in which potassium fertilization gave no response over a number of years, applications of this element are now necessary to obtain a response from phosphorus. Lodging of corn became severe due to a potassium shortage, particularly where higher rates of nitrogen were used. Winterkilling of small grain amounted to 90 percent on plots receiving no potash fertilizer, whereas much less killing occurred where adequate potash was applied.

Findings such as those made by the Missouri station may become evident only after a relatively long period of following given soil-management practices.

Interesting observations have been made on the effects of potassium deficiency in a rotation experiment at the Ohio station. During the period 1926 to 1944, plots in a 2-year rotation of corn and oats, with a legume green manure crop, were fertilized with phosphorus only. Potassium-deficiency symptoms became apparent on the green manure and corn crops, and yields became progressively lower. In 1944 the experiment was revised to include rates of nitrogen and potassium fertilizer as variables. Where potassium was added the sweetclover was more efficient in the storing of nitrogen, and the necessity of potassium fertilization for maximum corn yields in this rotation was established.

Over a period of 8 years striking results have been obtained from rotation experiments at the Nebraska station. Where 2 years of sweetclover were included in a 6-year rotation and manure was applied to the wheat, the average yields of other crops in the rotation were increased over the continuous grain plots as follows: Corn, 16.1 bushels per acre; wheat, 10.8; oats, 10.1; and barley, 9.6. These results are of importance to farmers in eastern Nebraska since a large part of the land there has never been planted to legumes and has never received manure.

Soil Chemistry and Fertility

Much basic research on the factors that govern the fixation, release, and available supply of plant nutrients in soils has yet to be completed before the related effects of the many soil and plant variables can be properly evaluated. The newer techniques and methods now available can be expected to accelerate the advance of knowledge in the general field of soil fertility and lead to practices that will permit conservation and will more nearly approach the desired economy in per acre production for the Nation's major soil types.

Potassium, phosphorus, calcium, magnesium

The New York (Cornell) station studied the release of nonexchangeable potassium by four different soils. The sand, silt, and clay fractions of samples of Dunkirk, Mardin, Honeoye, and Gloucester soil series, were examined separately. The rate of release of potassium from the nonexchangeable form was determined after varying periods, by extraction with neutral, normal ammonium acetate. The silt fraction of the four soils contributed from 30 to 50 percent of the potassium released. The clay fraction contributed from 50 to 75 percent (following moist storage, with exchangeable potassium removed). The characteristic level of exchangeable potassium in these soils could not be correlated with the mineralogical composition of the sand and silt fractions, but the Honeoye soil (which had the most exchangeable potassium) contained the largest amount of muscovite in the silt fraction. The characteristic level of exchangeable potassium and the release of nonexchangeable potassium agreed well with the respective potassium-supplying capacities of the four soils, as determined by crop growth.

The Massachusetts station has shown that the availability of elements to plants is influenced to an appreciable degree by the respective concentrations of the elements in the soil, and by the total capacity of the soil for holding nutrients in an easily removable form (exchange capacity). When calcium, magnesium, and potassium were supplied to a Merrimac fine sandy loam soil in both exchangeable and nonexchangeable forms, and the same ratios were maintained between the elements by using calcium, magnesium, and potassium bentonites, there was no appreciable increase in growth when the exchange capacity and total bases were doubled. When these were increased three- or fourfold,

however, there was a progressive increase in the growth of the Ladino clover. Even when the soil was well supplied with exchangeable calcium, magnesium, and potassium as bentonite salts, a marked increase in yield resulted when dolomitic limestone was applied.

Heavy rates of dolomitic limestone reduced the luxury consumption of potassium, whereas equally high rates of application of calcium and magnesium in exchangeable forms did not. A saving of 16 percent in potassium removal by Ladino clover resulted when the calcium and magnesium were maintained at a high level. Three tons of dolomite per acre along with 60 pounds of potash initially and 60 pounds after each cutting produced forage of desirable composition and yield. Single high rates of potash fertilization required greater rates of dolomitic limestone to maintain a high level of calcium and magnesium in the forage. Dolomite was superior to calcite for maintaining the proper calcium-magnesium-potassium balance.

Experiments dealing with factors related to the availability and release of potassium, calcium, and magnesium, were continued at the Ohio station. When soils were subjected to repeated extractions with 0.5 normal hydrochloric acid (with intervening dryings), the quantity of potassium in the successive extractions remained rather constant after the first. The removal of potassium varied from soil to soil, but the amounts released closely approximated the respective supplying-powers of the soils as determined by the growth of crops in the field or in the greenhouse. When samples of Crosby silt loam were saturated before drying with either calcium, magnesium, hydrogen, or ammonium as acetates, each of the first three elements had very similar effects on subsequent potassium solubility, while ammonium reduced the solubility of potassium by about one-half.

When water was percolated through soil held in glass cylinders, the leaching of potassium was slightly accelerated by calcium or magnesium carbonate additions in the absence of potassium chloride. The addition of potassium chloride gave no marked change in potassium leachability as the lime level was increased. Substitution of magnesium carbonate for calcium carbonate slightly decreased the movement of potassium in Wooster silt loam soil fertilized with potassium. The greatest movement of potassium occurred, in both the fertilized and unfertilized soil columns, when one-half of the calcium was supplied as the sulfate. In greenhouse experiments, using the same soil, yields of red clover were highest with the highest levels of potassium and calcium, whereas these levels had little effect on the yield of Sudan grass. Regardless of the soil potassium level, substituting one-half of the calcium carbonate with calcium sulfate caused a reduction in yield of both crops.

Little change in yield resulted when part of the calcium carbonate was replaced by magnesium carbonate. Increasing the potassium level materially lowered the quantity of calcium and magnesium in the forage, whereas changes in the calcium level

of the soil had very little influence on the potassium content of the plants. As the calcium level of the soil increased, the amounts of boron, phosphorus, magnesium, manganese, silicon, iron, aluminum, and potassium in Ladino clover decreased. Changes in the potassium level of the soil had less effect on the composition of the clover than did changes in the level of calcium. However, there was a general trend toward lesser quantities of boron, magnesium, and calcium in the clover with increasing soil levels of potassium.

Investigation of the activities of certain plant nutrient elements as related to different soil colloids was continued at the Missouri station. When mixed calcium-potassium and magnesium-potassium systems were used, it was found that the mutual influences of these elements vary greatly from one type of clay to another. In all clays examined the potassium-ion activity was considerably enhanced by calcium, whereas the effect of potassium on calcium activity varied according to the clay used. These findings promise to explain why liming sometimes affects potassium uptake by plants, and why potassium fertilization sometimes depresses calcium uptake. The fact that single cations are held on clay minerals with a wide range of bonding energies is further established.

The actual influence of the clay on ion activities is shown by the following results. When kaolinite was saturated 10 percent with potassium and 90 percent with calcium, approximately 80 potassium ions were found per 100 calcium ions. These same saturation values on Putnam clay, however, produced 400 potassium ions per 100 calcium ions. Hence, it is definitely established that differences in the kind of clay in the soil result in considerable differences in the nutrient environment of growing roots.

The Iowa station continued its studies on the role of organic matter in supplying phosphorus to plants. On a low-organic-phosphorus soil, both corn and soybeans responded well to phosphate fertilization, regardless of temperature, while on a high-organic-phosphorus soil, response to phosphate fertilization was marked only at 20° C. Inorganic phosphorus was apparently available at both temperatures, while organic phosphorus was mineralized more rapidly at the higher temperature. In other tests, in which several different soils were held at a low soil temperature, soluble inorganic phosphorus correlated with soil phosphorus availability to plants, while the oxidizable organic phosphorus did not. The reverse was true at high soil temperatures. In these latter tests, phosphorus availability was calculated from the plot yield data, using the Mitscherlich law, and the results confirmed those of the first experiments. In soils high in organic matter, mineralization of organic phosphorus was found by the Iowa station to be an important source of phosphorus for plant nutrition during the summer months.

Fundamental investigations were conducted on various forms of inorganic phosphorus by workers at the Wisconsin station. When precipitated iron (ferric) phosphate was held in warm water, in the laboratory, it readily crystallized and became less

soluble. In soils it was found that ferric phosphate formed hard concretions, with manganese dioxide and silicon, which varied from microscopic size up to a diameter of about 2 millimeters. The larger concretions consisted chiefly of a mixture of iron, aluminum, and manganese oxides, together with some silica, and usually contained 0.2 to 0.4 percent of phosphorus. Even though the composition of the concretions averages 5 or 10 times the phosphorus content of the whole soil, the phosphorus is very insoluble and unavailable. Much of the phosphorus in many soils may be tied up in this type of granule as basic iron phosphate, thus explaining its low availability.

The addition of lime to soils at the Wisconsin station transformed iron phosphate to the more available calcium phosphate at a much more rapid rate than has commonly been supposed. However, this transformation is largely limited to the finely divided ferric phosphate and does not occur appreciably in the granules or concretions. When soluble phosphate fertilizers are applied to soils, the ferric phosphate which results is in the finely divided form. This explains the much greater availability of added phosphorus as compared with that naturally present in the granules. This information is of great importance in enabling farmers to lime soils so as to render phosphorus more available to crops.

In studies employing different radioactive phosphorus compounds, the Colorado station (coop. USDA) reports that ammonium phosphate (11–48–0) and superphosphate were equally available to sugar beets, potatoes, wheat, barley, and alfalfa. Calcium metaphosphate and superphosphate were equally available for alfalfa and potatoes, but the metaphosphate was less available to wheat and barley. During the early part of the growing season, calcium metaphosphate was not as available as superphosphate for sugar beets, but was equally available later in the season. Tricalcium phosphate was least available to all of the crops tested. Liquid phosphoric acid added in irrigation water in late June to sugar beets and alfalfa was approximately equal in availability to superphosphate applied in bands below and to the side of the seed at planting time. Phosphoric acid in irrigation water was more available than superphosphate added at the same time (late June) as a side dressing. About 85 percent of the phosphorus applied in irrigation water remained in the top 4 inches of the soil. In certain calcareous soils, fertilizer phosphorus was removed from solution by a surface reaction between the phosphate ion and the calcium carbonate. Research of the nature of the Colorado experiments promises more efficient methods of phosphate application and offers leads for improved methods of soil analysis.

The movement of applied phosphorus was followed under field conditions by the North Carolina station (coop. USDA). On both the Bladen and Norfolk soil series, the movement of phosphorus was only slightly affected by the rate of movement of water. The principal factor governing the movement of phosphorus was

found to be the amount of acid-soluble phosphorus (0.2 normal sulfuric acid) already in the soil. In the Norfolk soil, added phosphorus moved readily through zones in which the acid-soluble phosphorus exceeded 300 parts per million P_2O_5. The movement was marked, but reduced in zones containing 200 to 300 parts per million P_2O_5, and negligible when the soil contained less than 200 parts per million of acid-soluble P_2O_5. Results with the Bladen soil confirmed those on the Norfolk and, in addition, showed that the lateral movement was restricted to 2 to 3 inches when the phosphorus was applied in bands. Such findings may be of considerable practical significance in guiding farmers in their use of phosphate fertilizers. Since the movement of phosphorus is very slight when the soil is low in acid-soluble phosphorus, farmers would be safe in applying large quantities of phosphate fertilizers to such soils during periods of favorable price relationships.

Soil-Water Relationships

The ability of soils to supply moisture is a major factor in crop production, even in the humid areas of the country, and supplemental irrigation is increasing rapidly for the production of both horticultural and field crops. In the dry-land areas, irrigation is necessary for most crops, and the number of acres under irrigation is increasing rapidly.

Although water-soil problems have been studied in the Western States for about 40 years, past research has not included all of the factors necessary to answer such questions as how to prevent soil deterioration, maintain crop yields and quality, and obtain efficient use of water and added plant nutrients. An extensive irrigation experiment involving two methods of irrigation, four moisture levels, four crops in a 5-year rotation, and selected fertilizer treatments is now being conducted regionally by western experiment stations (coop. USDA), with headquarters at the Utah station. Some interesting trends are beginning to show up in this research. Some of them indicate that an increase of about 2.5 tons of sugar beets per acre could be expected from the proper moisture level and fertilizer practices, which at $10 per ton for sugar, would result in an annual increase of about $2,000,000 for the State of Utah alone. Thus far the irrigation practices used for potatoes have increased yields about 50 bushels per acre. On the basis of $1 per bushel, this would add about $750,000 to Utah's agricultural income. Indications are that alfalfa yields can easily be increased ½ ton per acre through the use of good irrigation practices. If the hay is considered to be worth $5 per ton, the increase for this one State would be approximately $1,000,000 annually.

Research by the Texas station (coop. USDA) shows that when rainfall is conserved on heavy clay loam soils, it will help increase the yield of cotton. Where cotton was planted continuously for 23 years in rows up and down the slope, the average yield was 193 pounds of lint per acre. When the crop was planted on the contour on terraced land, the yield was 534 pounds of lint

per acre. This represents almost a three-fold increase in the annual yield of cotton throughout the 23-year period, as the result of practices which favored the conservation of water and soil. In other experiments, it was found that fertilizer and manure were much more effective in increasing yields on land where terracing and contour farming were practiced. In grazing studies, light stocking produced higher steer gains and deeper penetration of moisture in the soil with a resulting improvement of grass cover.

In areas of the country where power or flood-control dams have been constructed, resulting changes in the depth of the prevailing water table may become an important matter in crop production. The Vermont station studied the effects of different water table depths. Out of this research came indications that many of the common hay and pasture plants can tolerate higher water tables than heretofore suspected. In 1949 maximum yields were obtained on those plots where the average water table was about 2 feet below the surface of the soil.

The Iowa station, in research seeking to learn how different crops affected soil moisture, reports that soybeans on a Webster silty clay loam depleted the moisture in the surface 6 inches faster than corn. The difference became less as the soil became drier.

Numerous soil-water researches have been undertaken by the California station (coop. USDA). They deal with problems of soil-air and soil-water relationships during irrigation; the effects of chemicals on reduction of the salt content of soils; and the maintenance of desirable infiltration rates. In experiments in Kern County, the use of gypsum in irrigation water greatly improved the infiltration rate of the soil. The need for frequent irrigation was reduced, with a considerable saving to farmers. Before treatment with gypsum, some soils were wet only 6 inches in depth with a 10-hour irrigation. Following treatment, water penetrated to a depth of several feet with each irrigation. The water used had a relatively low total salt content, but sodium constituted over 50 percent of the total bases present. It had been thought that damage or "scalding" injury to forage crops was caused by the high temperature of the irrigation water. The California research showed that the damage is due to failure of the plant roots to get enough oxygen. When air and soil temperatures are high, the respiration rate of the plant may be so high that the amount of oxygen left in the soil following irrigation is too small.

Normal growth of corn was obtained by the New York (Cornell) station in soil cultures with 6 percent of oxygen or more. Tomotoes made normal growth at levels of oxygen down to 3 percent, and with carbon dioxide as high as 45 percent by volume, indicating that the amount of oxygen in the soil air may not be a useful criterion for describing the aeration status of soils.

Soil Microbiology

The effects of DDT, BHC (benzenehexachloride), and chlordane on the ammonifying, nitrifying, and total number of soil bacteria,

were studied by the Utah station. Concentrations as low as 0.125 percent of DDT, BHC, and chlordane were found to be toxic after a period of 2 years. In lower concentrations chlordane was slightly toxic at the end of 6 months to ammonifiers and nitrifiers in the concentration of 0.001 percent, whereas BHC and DDT were not toxic at 0.01 percent or less. Analysis of the soils for DDT at the end of 1 year gave no evidence that it had decomposed at any of the concentrations used. Chlordane tended to depress the total number of soil organisms, whereas BHC and DDT had little effect upon total numbers.

The usual field rates of application of 2,4–D as the ammonium salt, on plots at the Idaho station, did not interfere with legumes the following year. No residual action was noted in soils held in the laboratory in a warm-dry or warm-wet condition. Only a slight residual action was noted in the soils held in a cold-wet condition between the first and second crops. The nitrogen content of the second crop was equal to that of the crop grown in untreated soil. Attempts to demonstrate 2,4–D breakdown by microbial activity failed.

The New Jersey station developed a biological-assay procedure for determining the streptomycin content of soils. Added streptomycin did not decompose in sterile soils, but underwent slow decomposition in a normal soil, and completely disappeared in 2 weeks. It was found that soil colloids adsorb streptomycin and that in the adsorbed state it still exerts an effect upon micro-organisms.

The New Jersey station also conducted experiments on the production of growth-promoting substances by soil micro-organisms. Vitamins of the B-complex, riboflavin, pantothenic acid, and certain auxins were very susceptible to microbial attack. Although these substances are produced by micro-organisms, the amounts present in the soil at any given time depend upon the equilibrium between production and decomposition processes. Even in periods of rapid microbial build-up, their persistance is brief.

Soil Formation and Mineralogy

A total of 10 profiles, ranging from neutral brown forest to acid gray brown podzolic soils, were studied by the New York (Cornell) station (coop. USDA) in order to determine differences among recognized and proposed units used in soil classification and mapping. As the acidity of the A and B horizons (solum) increased, total organic matter decreased, thickness of the A_2 horizon increased, as did the maximum clay content of the B horizon, and the loss of aluminum was speeded up with respect to silica, iron, sodium, potassium, and calcium. Increasing soil acidity apparently hastens the loss of clay minerals and micas as compared with the loss of quartz, feldspars, and other primary minerals which are normally considered less resistant to weathering than clays, but which occur dominantly in the coarser-size fractions.

At the Missouri station, a series of feldspars was subjected to the weathering action of electrodialized hydrogen clay for a period of about 100 days. The different weathering rates corresponded to the calcium content of the feldspar. Anorthite, the mineral with the highest calcium content, weathered the most rapidly. Determination of the feldspar content of the silt fraction of different Missouri soils showed that the soils of the Ozark region had undergone a much higher degree of weathering than those of northern Missouri. The study of weathering of soil minerals of the silt fraction appears to offer possibilities for estimating the reserve fertility of soils.

The investigation of soil properties related to agricultural use will be facilitated by a simplified method of specimen mounting for X-ray spectrometer studies, developed at the Connecticut New Haven station. Mineral samples, ground to pass through a 300-mesh screen and mounted without the use of binding materials such as ethyl cellulose and collodion, gave reproducible X-ray spectrograms, even for minerals having highly preferred orientation. Standard spectrograms of quartz, muscovite, biotite, chlorite, calcite, gypsum, orthoclase, and all of the plagioclases, have been prepared for use in studying the different minerals in major soil types of the State.

Plant Physiology and Nutrition

Fundamental research in the field of plant physiology has increased considerably in the past 10 to 15 years. The uptake of nutrients by plants and their utilization in growth processes is so extremely complex that concrete advances in knowledge come about very slowly.

Nutrient uptake varies with conditions

The California station reported that application of phosphate to soils increased the molybdenum uptake of plants as much as tenfold. The application of gypsum resulted in decreased molybdenum uptake by as much as one-half to one-fifth of the normal amount. The molybdenum content of plants was raised from levels safe for cattle to unsafe levels through the application of phosphatic fertilizer on soils of moderately high molybdenum content, whereas unsafe levels were reduced by applications of gypsum. On soils low in molybdenum, acute plant-deficiency symptoms were induced by the application of sulfates. In California counties where molybdenosis in cattle is serious, county agents are now in a position to analyze crops for molybdenum.

The Pennsylvania station found that the leaves of peach trees showing intervenal chlorosis contained much less manganese than normal leaves. Where chlorotic symptoms did not appear, manganese was 45 percent higher than in chlorotic leaves. Nitrogen and iron were also significantly lower in the chlorotic leaves.

Chlorosis of crop plants has been a problem in certain areas of the West for many years. The problem has been especially acute on peach trees, and the Utah station has conducted extensive

experiments to determine the cause and to find remedies. Iron chlorosis was found in 23 percent of the orchards studied, manganese deficiency in 18 percent, and zinc deficiency in 6 percent. Soil analysis failed to show a difference in the composition of soils from normal and manganese-deficient areas, but soils from zinc-deficient areas were unusually high in phosphorus. Peach growers now have recommendations for the treatment of iron, zinc, and manganese deficiencies.

As a contrast to soils in which the available supply of an element such as manganese is limiting, there are certain areas in the humid sections of the country where this element may be present in toxic amounts. Pennsylvania station research indicates that soluble manganese is a major cause of plant injury resulting from soil acidity. Manganese was found to be very high in plants grown on acid soils. Limestone was much more effective in reducing acidity and decreasing both soluble manganese and aluminum when it was thoroughly mixed with the soil. The rate at which decreases in manganese and hydrogen-ion concentrations occurred in the soil was related to the fineness of the liming materials. The solubility of the different particle sizes in dilute acetic acid provided a good advance index of their rate of reaction in the soil.

Corn, alfalfa, and red clover plants grown in solution culture at the New Jersey station produced excellent growth over a range of manganese from 0.05 to 2.0 parts per million with iron at 0.05 part per million in all cases. Soybeans grew best at a manganese concentration of 0.1 part per million. Corn was the least susceptible to manganese deficiency and alfalfa, red clover, and soybeans followed in order. Corn was also the least susceptible to manganese toxicity, followed by red clover, alfalfa, and soybeans. Where plants were grown with increasing levels of manganese, iron accumulated on the root surface, and decreasing quantities of iron were found in the tops. Symptoms of mild manganese toxicity were distinguishable from those of iron deficiency; however, severe manganese deficiency symptoms closely resembled those of iron deficiency in the soybean. The level of manganese was consistently higher and iron was consistently lower in soybean plants grown in the winter than in those grown during the spring. Manganese toxicity of soybeans occurred at a lower manganese level during the winter months. The effect of three sources of nitrogen on manganese content of snap beans and soybeans was studied. Where nitrate nitrogen was used, the manganese content of both crops was highest. It was intermediate for urea, and lowest where ammonia nitrogen was used in the culture solution. The availability of soil manganese was governed most by the soil pH, but organic matter and soil moisture were also important factors. Research with other trace elements showed that sodium molybdate at the rate of 1 pound per acre increased the yield of alfalfa up to 30 percent and also increased the amount of protein in the crop. No growth response resulted from iodine applications, and 5 parts per million were

toxic to tomatoes. The iodine content of New Jersey soils varied from 0 to 12 parts per million.

Studies of the uptake of calcium by alfalfa, with the use of radioactive calcium, at the New York (Cornell) station, showed that changes in the concentrations of manganous or hydrogen ions did not appreciably affect the uptake of calcium within the 4.5 to 6.5 pH range in nutrient solutions. The presence of aluminum ions, however, markedly reduced the absorption of calcium by the plants. Liming reduces soluble aluminum in acid soils and thus provides more favorable conditions for uptake of essential nutrients.

Sulfur studies

Samples of rainwater were collected by the Indiana station and analyzed from sites in 11 different areas in the State to learn the rate of natural replenishment of sulfur in soils. In rural areas the addition of sulfur by rainwater over a 3-year period averaged as low as 33.4 pounds per acre per year. Near the industrial area of Indianapolis an addition of 66.7 pounds of sulfur occurred. At most of the collection sites there was considerable variation in the addition of sulfur between years. Applications of sulfur increased the quantity of certain amino acids in alfalfa, as well as the amount of sulfur. On Maumee sandy loam soil, sulfur additions corrected manganese deficiency and increased wheat yields 10 bushels per acre. A similar increase was obtained for soybeans. As the use of concentrated phosphatic fertilizers becomes more common, increasing attention may have to be given to the sulfur status of soils.

The Indiana station also studied the absorption of sulfur directly from the atmosphere by plant leaves. Experiments in which radioactive sulfur (S35) was used in sulfur dioxide provided further evidence that plants readily take up sulfur through their leaves. Plant analysis showed that the organic fractions contained large amounts of the absorbed sulfur, thus proving that atmospheric sulfur is reduced and stored by the plant. Sulfur entered into both organic and inorganic compounds in all parts of the plant, and, in addition, some of the sulfur absorbed through the leaves readily passed from the roots into the nutrient solution.

Sulfur increased the protein content of the alfalfa grown in experiments at the Oregon station. When sulfur was used with boron, the leafiness and carotene content of alfalfa were also increased. Over a 5-year period, sulfur increased alfalfa yields by 1.02 tons, and where boron was also added, the increase was 1.1 tons per acre. Sulfur was more effective than gypsum in increasing alfalfa yields on nearly neutral soils. Lambs fed alfalfa from these experiments made the greatest gains on the sulfur-fertilized alfalfa. Those fed alfalfa from the sulfur-boron plots made the next most rapid gains, whereas the group on the unfertilized hay made the slowest gains. The latter group of lambs required more hay per unit of gain. Those receiving the hay from the sulfur or the sulfur-boron plots produced a slightly higher total weight of fleece over a 9.5-month period.

Nitrogen metabolism of corn

Extensive studies of the nitrogen metabolism of the corn plant have been conducted by the Illinois station. The germ and endosperm constitute about 11 and 82 percent of the corn kernel, respectively, and the germ contains a higher concentration of nitrogen than the other parts. About 53 percent of the germ nitrogen was water-soluble and 4 percent alcohol-soluble, whereas about 4.5 percent of the endosperm nitrogen was water-soluble and 40 percent alcohol-soluble. In breeding or fertilizing for high protein, the endosperm nitrogen was modified to a greater degree than that of the germ. Just after pollination there is enough nitrogen in the plant to supply the maturing grain if it could all be translocated. An average of 54 percent of the nitrogen in the plant at this stage was translocated into the grain during its development, whereas 46 percent of the grain nitrogen came from the soil and roots. Protein and protein derivatives in the leaves seem to contribute the major part of the nitrogen to the grain. Good yields of corn on fertile soils may result from the accumulation of high concentrations of nutrients during periods favorable to absorption, and the later utilization of these nutrients in sustaining plant activities during less favorable periods.

Nitrate accumulation in plants

In the Black Hills of South Dakota, certain plants tend to accumulate nitrates in large amounts. In drought years the nitrate content of cereal hay is frequently high enough to cause losses of cattle and sheep. Samples of oat plants obtained in the milky to soft-dough stage contained 2.91 percent potassium nitrate (air-dry basis) for the Black Hills samples, whereas those from eastern South Dakota contained only 0.92 potassium nitrate. The potassium nitrate content of the soils averaged, respectively, 72 parts per million and 27 parts per million for the two areas of the State. Beet tops which had been accidentally sprayed with 2,4–D were also analyzed for nitrogen by the South Dakota workers. The sprayed leaves contained the equivalent of 5.5 percent potassium nitrate but the untreated leaves contained less than 1 percent. Since 2,4–D is widely used, this may be an important finding, especially for areas of the country where nitrates tend to accumulate naturally to toxic levels in plants.

Translocation of 2,4–D in plants

2,4–D, synthesized with radioactive carbon in the carboxyl group, was used by the New York State station to treat bean plants which were then harvested at intervals of 6 hours, 2 days, and 7 days. From 25 to 60 percent of the radioactive carbon in the 2,4–D was absorbed by the plant. Radioactive carbon was detected in the carbon dioxide produced by plant respiration, and also in the nutrient solution in which the plants were grown. Most of the radioactive carbon was accounted for, however, in two compounds: Unchanged 2,4–D, and an unidentified water-soluble compound which could not be extracted by ether from an acid-water solution.

AGRICULTURAL ENGINEERING

One needs only to look back to the turn of the century to measure the contributions of agricultural engineering to farm technology. Many of the great strides in plant and crop improvement could not have been made without parallel progress in the development of machinery and better tools suitable to various farming areas. During the past 50 years the corn planter, the combine, and pneumatic rubber tires for farm tractors and equipment were introduced. Major improvements on the cultivator, the grain binder, and spraying equipment, to mention only a few, took place. The experiment stations cooperated closely with practical farmers, with farm equipment and machine manufacturers, and with the Department of Agriculture in all this development. Agricultural engineering projects at the stations have for their objectives to develop better methods of production, harvesting, storage, and preservation of the crops, as well as equipment to enable farmers to produce their crops with less drudgery and at a greater margin of return for the capital invested and the efforts put forth. A few examples of the most recent findings in agricultural engineering research at the stations are reported in the following pages.

All-purpose crop drier and conditioner

Cooperative research with industry on the development of an all-crop drying building has been under way at the North Carolina station. A satisfactory structure of this type has been developed and erected at this station. To date, test runs have been made on ear corn, wheat, oats, baled hay, and sweetpotatoes. All have been satisfactorily conditioned to moisture contents that are safe for stored crops. Cost of drying small grains averaged 10 cents per bushel and seed corn 8 cents per bushel. Sweetpotatoes, cured for 10 days and then stored for 5 months in the building, gave a total operating cost of 9½ cents per bushel. Baled hay was dried at an average cost of $1.72 per ton. A crop-drying building of the design developed costs between $4,000 and $5,000 complete.

Mechanized tobacco harvesting

The Maryland station has reduced the amount of hand labor required in producing southern Maryland tobacco. Under present-day harvesting, a sharp, steel spear is fitted on a pointed stick 4′ 4″ long and ¾″ x 1″ wide and broad. About six plants are darted on each stick after they have been cut and left on the ground until the leaves become limp. The filled sticks are then hung in the barn to cure. Approximately 850 of them are needed for each acre of tobacco grown. The preparation of sharpened ends to fit the steel spear represents a sizable hand operation requiring many hours of tedious work. The sharpening of the sticks is done away with in the new Maryland machine, built like an over-sized pencil sharpener. One man can sharpen 400 sticks per hour, which is better than 2½ times faster than the hand

method in which a hatchet is used. Further, the taper produced is smooth and uniform, producing a close fit with the steel spear. The sharpener is operated at a speed of 3,000 revolutions per minute and a test run in which one man and a helper were used demonstrated that production of more than 700 sticks per hour is possible.

Practical sweetpotato diggers

During the past two years the South Carolina station has developed a rod-type digger which seems to be a practical answer to the complex problem of digging sweetpotatoes by machine. Machines tried previously for this purpose left too many potatoes covered with soil. In trials during the past season the new machine exposed an average of 96 percent of the roots. When this machine becomes commercially available, it is expected to reduce the cost of digging sweetpotatoes by $20 per acre.

The Louisiana station has also made considerable progress in mechanizing the production of sweetpotatoes. A commercial potato harvester, modified to dig sweetpotatoes, was used for the second season. In order to do an effective job of harvesting, the vines had to be removed from the row and preferably the crowns cut from the potatoes. Four to five men on the digger handled from 4 to 6 acres, which yielded 300 to 500 bushels per acre in a 10-hour day. Ordinary practices of digging and loading would require 24 to 30 men to do this job in one day.

Self-cleaning screen for sprinkler irrigation

The screening of trash from waters used in sprinkler irrigation has been a serious problem. To keep sprinkler nozzles from becoming clogged, the Idaho station has developed a self-cleaning screen that will filter surface waters of trash before it can get into the sprinkler system. The screen will save an estimated equivalent of a 0.5 man-hour per day per 40 acres of normal-surface ditch waters in the irrigated farming sections of Idaho.

Setting fence posts mechanized

A pile-driver type of machine for setting fence posts rapidly has been developed by the Minnesota station (coop. USDA). The machine does away with post-hole digging, mechanically or by hand. It enables a 3-man crew to set 40 fence posts in 1 hour, as compared with 12 posts set in 1 hour by 3 men working by hand.

Two inventions meet Wisconsin's haying problem

Some years ago hay "crushers" were developed which crack the hay stems as they are cut, thus allowing the stems to dry more quickly with shorter exposure to weather and less shattering of the leaves. During the past year, the Wisconsin station developed a "hay kinker" which puts bends into the cracked hay stems which result in uniformity in the drying of stems and leaves. The cracked stems are held open by the bends and drying

time is shortened. The kinker uses corrugated rollers instead of the smooth rolls of the crusher. The kinker cracks and bends the stems in one operation. It has another advantage in that the corrugations provide a positive flow of the material going through the rolls. The smooth rolls on standard crushers often slip when a large amount of material is fed to them. The kinker allows hay to dry more quickly with shorter exposure to weather, an advantage under the relatively high humidity conditions encountered in Wisconsin during the haying season.

The Wisconsin station also completed a greatly improved field forage harvester during the year. Standard machines ordinarily chop the hay into rather short lengths which may knock off many of the leaves and thus cause a loss of feed value, or may injure the animals' mouths. Streamlining of the cutter head and redesigning of standard machines have produced a forage harvester which will make long cuts with less leaf shattering and with reduced power requirements. The length of cut is easily and quickly adjustable to permit fine chopping of grass silage.

Health protection from septic tanks

The proper location of wells and septic tanks to assure rural home owners of sanitary water supplies is the objective of research at the Massachusetts station. Results thus far, both in the laboratory and in septic-tank disposal fields, have shown that few *Escherichia coli* organisms penetrate into the light, sandy loam soil of disposal fields and that these do not survive for more than a few days. No *E. coli* bacteria have been found more than 5 feet from disposal lines. The *E. coli* organism is employed as an indicator of sewage pollution of water supplies and should be equally adequate for soils.

Additional results also show that disease-producing intestinal bacteria, such as the typhoid and dysentery bacilli, would not penetrate the soil to a greater extent than *E. coli* and would survive for an even shorter time. The virus of infantile paralysis has been found in sewage, but nothing is known of its ability to penetrate or survive in soil. Adequate procedures are not available for a study of this virus. Results obtained for *E. coli* cannot be depended upon to indicate freedom from this organism.

Improved drainage practice produces more sugar

The Louisiana station (coop. USDA) has been engaged in research on the problem of drainage for sugarcane land for the past 6 years. This joint undertaking with the Department has developed methods and tested equipment for grading the sugarcane planting beds with a crown. This grading is often called turtlebacking. Grading with this equipment on 105.6 acres increased yields 5.84 standard tons of cane and 1,267 pounds of sugar per acre. The maximum yields were obtained with 13 inches of crown per 100 feet; the precision with which the grading was done had a definite bearing on yields. The practice demonstrated that small pockets 2 inches high or over should be kept to a minimum.

To date, 70,000 acres have been graded (turtlebacked) as a result of this research. In order to facilitate the cleaning of lateral ditches, those engaged in the research on the equipment have developed a sloping side bucket for use with draglines. Three manufacturers are building this bucket, and approximately 40 buckets are now in use in the cane area.

Specialized tractor for cranberry bogs

During the past year, the Massachusetts station developed a specialized tractor which satisfactorily operates in the cranberry bogs, thus bringing to the industry some much-needed mechanical power. The machine weighs about 1,500 pounds and develops from 8 to 10 horsepower. Wheels and tires have been designed so that the weight is distributed to about the same pressure as is exerted by a man walking across the bog. Attachments for spraying, dusting, pruning, raking, harvesting, ditch cleaning, and sanding (should this operation prove necessary) are in the process of development. When these special cultural attachments become available, cranberry production costs are expected to be cut between $1 and $2 per barrel.

New "comfort" stall for cows

The West Virginia station reports development of a new "comfort" stall for cows. Seven cows housed in it produced 2 to 12 pounds more milk daily for a minimum 14-week period than did an equal number of cows confined in standard tie-chain stalls. Five out of the seven cows remained cleaner in these new stalls than those in the tie-chain type. There was no difference in the daily requirements for bedding for either type of stall nor in the time required to clean them. Two months after stabling, seven cows in the tie-chain stalls showed injuries as compared with one in the comfort stalls. Cows in the tie-chain stalls spent 8.8 hours per 24-hour period lying down as compared to 10.2 hours per 24 hours for cows in the comfort stalls.

The new comfort stall is 84 inches long by 49 inches wide, with an adjustable cross bar near the dropping pit. The tie-chain stalls used as a standard in the experiments were each 66 inches long and 42 inches wide.

New materials for farm buildings

In a cooperative regional research project, 12 North Central stations (coop. USDA) are studying new building materials and the more effective use of those now generally employed, as well as new construction and fabrication methods, to effect savings to farmers.

The Illinois station reports that aluminum and aluminum products used in the construction of a poultry house have given satisfactory performance. No corrosion, even from contact with wet litter and droppings, is evident. Atmospheric conditions are comparable to those in conventional houses. The Iowa and Illinois stations have found that aluminum roofs reduce air

temperatures in farm buildings. The Michigan station finds that building blocks made of ground corncobs and cement work well and are easy to handle. Their insulating value is about the same as cinder-concrete blocks. The South Dakota station has devised low-cost, hard-surfaced floors for farm buildings made of labor-saving materials. The Indiana station reports encouraging results in developing a building panel of agricultural waste plant material. The possibility of bonding cornstalks into building boards seems feasible, and the experimental panels are undergoing further tests of their suitability and durability for the rigid requirements of floors, ceilings, walls, and roofs. So far, it appears that little framing will be required when the panel is used in construction, but most important is its low-heat conductivity.

New duster developed to combat corn earworm

The Utah station (coop. USDA) has announced developement of a new type of insecticide duster for use with corn. This machine has a long boom, attached to one side, which can be easily raised or lowered according to the height of the corn. With two rightly timed applications of 10-percent DDT dust, the machine did a good job and caused very little damage to the standing corn.

Mechanized Production, Harvesting, Cleaning, and Ginning of Cotton

Cotton is produced in five general classified areas of the South—the Piedmont, Coastal Plain, Alluvial Plain, Subhumid Plain, and Irrigated—variable as to climate, soil, and topography, and each with its peculiar and particular problems. Many of these areas have mechanization problems common to others that can be solved in one locality for the benefit of all, but many problems are isolated and specific and cannot be correlated with others. Planned regional research (coop. USDA) has, therefore, been designed to obtain information on ways and means of producing cotton mechanically through all operations from residue disposal to crop harvesting, storage, ginning, and cleaning. Individual cooperators accepted responsibilities for conducting original researches on problems common to several areas as well as those which were special to local conditions, the results obtained being pooled for the benefit of all.

Recent results from this program are encouraging and indicate that progress is being made toward final achievement of all the original research objectives.

Results of tests of power-driven stalk shredders by the Alabama, Mississippi, and Texas stations indicate that the power requirements are high and mechanical failures excessive in most machines, and that improvements are needed in most of the commercially available shredders for adequate disposal of crop residues. One type, however, which incorporated a revolving, vertical blade gave outstanding performance in cutting ability

and durability. The Texas station has developed a root slicer for cutting plant stalks immediately above the root crown. Its use alone, or as an attachment to stalk cutters, facilitates other mechanized operations. Measurement of the effect upon insect control through county-wide stalk-destruction programs was initiated by the Texas research workers. Where all stalks were destroyed by September 1, boll weevil infestation was held to 27 percent, whereas in the adjoining county with no control the infestation reached 63 percent on the same date.

The Alabama and Tennessee stations report that a small subsoiling plow used in conjunction with a moldboard plow has given significantly increased crop yields. This cultural operation apparently stimulates greater plant vigor since stalk height is increased due to the development of a long, tapered plant root system as compared with short, malformed roots developed under other tillage practices.

The Mississippi and the Texas stations have found that hill-dropping of cottonseed is both economical and practical. Planting speeds of 4 to 4½ miles per hour, using 20 to 22 pounds of seed per acre, gave satisfactory stands. In precision planting studies conducted by Oklahoma station personnel, it was found that percentage of crop stand is directly proportional to the number of seeds planted and their viability, thus dispelling the theory that thickly planted seed gives a better crop stand because of more combined "push" to break through the soil.

Preliminary results with an experimental precision planter in Arizona indicate that by its use cotton thinning can be eliminated and seed saved by planting only 9 pounds of acid-delinted seed to a stand. The Oklahoma station has demonstrated that it is possible to hill-drop or drill at desired rates and spacings with a lister planter by using special mechanisms, special seed plates, and graded, acid-delinted seed. The grading of cottonseed for planting purposes is new, but this practice is well established with other crops.

Tests of a newly devised, electrically actuated lip valve, produced by the Texas station, which is free of cumbersome sprockets, chains, and shafts showed that it satisfactorily hill-dropped machine-delinted seed at speeds of 4 miles per hour. A boatlike piece of wood placed on the bottom and in the notched part of the runner opener aided in securing a firm seedbed free of loose dirt. Good stands were obtained despite 6 inches of rain at the time of emergence.

Engineers at the North Carolina station have developed an experimental machine to measure the efficiency of differential placement of fertilizer ingredients. The machine is capable of placing phosphate with the seed mixed in the drill and in bands 3, 9, and 15 inches from the drill at varying depths on either or both sides of the drill. Nitrogen and potash can also be placed simultaneously in bands 3 inches on either side of the drill from a top-delivery hopper. This special equipment has permitted the application of tagged, radioactive fertilizer. It has been shown

that in about 2 weeks, cotton roots take up this radioactive fertilizer from fertilizer bands placed 3 inches from the row, from 9-inch bands in 60 days, and from 15-inch bands in 75 days after planting. The highest initial uptake of fertilizer occurs when it is placed with the seed or in the 3-inch bands. Further work may lead to differential placement of the various fertilizer ingredients used in the production of the crop.

Attempts to establish methods for grass and weed control through the use of chemicals and flaming have been conducted by all cooperators. Dinitro pre-emergence sprays gave good control for 6 weeks in Arkansas and reduced hand-hoeing 60 percent.

Georgia reports that the application of spray-emergence chemicals combined with sweeps and a combined use of sweeps and flame was not satisfactory for controlling weeds and grass. The Louisiana station, however, indicates that flaming followed by dinitro chemicals applied before emergence resulted in the elimination of all hand-hoeing. Flaming alone controlled weeds before planting and had little or no residual effect after emergence. Experiments in Georgia gave the same results.

The use of the rotary hoe for mechanical post-emergence weed control, when used in conjunction with high-speed sweeps set flat, reduced hand-hoeing to 15 man-hours in Mississippi.

Texas reports that when rotary hoes were used in combination with a lister cultivator, hoeing was reduced 16.8 percent during one year, but that it was reduced nearly 60 percent over a 3-year period for the high plains area of the State where seasonal variations greatly affect weed population. The performance and wearing quality of the hoes were better than those of the standard lister-cultivator equipment because they had separate spring-loaded mountings and hardwood, dustproof bearings. Late cultivation under irrigation in California is a problem that is being solved by the use of shielded equipment. A shielded tractor with only 18-inch clearance was used to cultivate and control weeds in cotton 44 inches high without damage. The effect of the row profile left by late cultivation in California and Texas on furrow irrigation and mechanical harvesting is receiving attention. Both States have accomplished a smoother profile by adding extensions of similar design to the wings of standard, rear-cultivator sweeps.

Recent developments in flame cultivation in Mississippi include a new flat-shape burner that operates at an approximate angle of 45° with the ground line. This burner employs a regular spray-jet tip which allows the fuel to enter the burner shell in a fan-shaped pattern, producing a broad, short flame. Higher operating speeds have been possible with this new burner, and the smaller jets permit flaming at an earlier date, reducing the possibility of damage to young plants.

An experimental machine has been built by the Mississippi station to use in applying both spray and dust materials for insect control. The spray-jets are directed into the air blasts of

the duster spreaders, giving coverage and control with rates as low as ½ gallon per acre, which compares with airplane application of dusts. When mounted on a high-clearance tractor with special shields, ground application to large cotton can be accomplished with slight damage to the plant. This station has also developed a spray machine that can be directly attached to a tractor-cultivator, thus permitting the spraying of insecticides during cultivation. It will give effective control of both thrips and boll weevil during normal cultivation, and there is no labor charge for application except for the filling of the insecticide tank.

Tests in Oklahoma have shown that the stripper-type harvester is more adaptable to that area than the spindle-type picker. Station engineers have designed and built an experimental stripper, incorporating a new stripping principle. The mechanism consists of two oppositely turning rolls upon which brushes are mounted. The plants pass between the two revolving brush rolls which sweep the cotton off the plant and into an inclined receptacle, where air picks it up and conveys it into a trailing wagon. The advantages of this mechanism over present commercial machines are as follows: It is simple in operation; it is potentially easy to manufacture; and it can be mounted directly on standard farm tractors. It operates satisfactorily. It does not uproot cotton stalks, gathers very few branches and stems, and the crop losses from using the machine were very low. Seven pilot models for tests in 1950 are being manufactured.

The Mississippi station reports that the use of wetting agents for spindle pickers reduced the amount of water needed for their successful operation. Their detergent qualities tend to keep spindles cleaner under adverse conditions. Except under ideal picking conditions, textile conditioning oils used in place of water did not clean the spindle satisfactorily.

Alabama, California, and Texas found that slight dirting of the drill row results in a cleaner row for the harvester, as defoliated leaves and stems then tend to fall to the lower middles. The well-shaped, dirted drill row is also essential for late-furrow irrigation in California and Texas.

Mississippi found that flat, clean cultivation, including flaming, gives the most desirable picking conditions. Flaming tended to prune the lower limbs of cotton plants and to present a higher fruiting plant for ease of mechanical picking.

Mechanical pickers of the spindle type have been found to do an efficient job of picking in the Piedmont, Coastal Plains, Alluvial Plains, and the Irrigated area. The principal disadvantages of the picker to date, especially in the Piedmont and Coastal Plains, are the high cost of the machine and the relative small size of farms in these areas. If full utilization of the machine can be made, the cost per bale is not excessive as illustrated by figures from Texas where 67 bales were custom-harvested at $17.79 per bale including depreciation and all costs.

FARM ANIMAL RESEARCH

Considerable space is devoted this year to reporting research in plant breeding and improvement. Such research is intimately associated with livestock husbandry and the national trend to grassland farming. In addition to helping farmers overcome tremendous losses from soil erosion, the newer rotation practices and adapted varieties of legumes and grasses enable more farmers to engage in the profitable production of livestock products. Research in plant breeding and improvement is matched at the experiment stations by equally significant research in the various animal production fields, in dairy, animal, and poultry husbandry. All of these research projects are making important contributions toward the bringing about of balanced farming as well as a better-balanced nutrition for the whole population. A few recent outstanding accomplishments in farm animal research, some of them closely related to plant research, are summarized in the following pages.

Research Protection Against Drought

Drought and the great damage it carries in its wake can never be ruled out as a major risk to the livestock industry. Among farmers and ranchmen who remember the devastating days of the thirties, questions concerning the contingency of drought keep constantly cropping up. One question that is uppermost is this: If and when another drought comes, will the livestock industry be prepared to prevent losses, or to minimize them? Livestock operators naturally look for help to their experiment stations. And the stations, in turn, can't wait until the drought comes before testing emergency measures. They are busy now, attempting to solve such questions as whether, in cases where green feeds are not available, some other materials, particularly low-grade roughages and high-cellulose substances, can be made available.

The problem of utilizing roughage of poor quality is not a new one, as usually three things are lacking. These are protein (nitrogen), minerals, and vitamins. Previous research at some experiment stations and in the Department showed that protein deficiency can be made up in a large measure through the use of urea [$(NH_2)_2CO_2$], especially in the presence of an easily available carbohydrate such as molasses. Recent information from the New York (Cornell) and Oregon stations indicates that the addition of the sulfur-containing amino acid methionine improves the ration when urea is fed. This is true particularly for sheep, since sulfur is important in producing wool of good strength.

The problem of minerals, although complex, is not difficult, since for the most part these can be supplied in salt licks or mixtures.

An inadequate vitamin supply, however, becomes a very serious factor. Although vitamin supplements can be fed they usually are expensive, and consequently green leaf roughages are usually depended upon as sources of vitamins A and D.

Agricultural researchers, both in the States and in the Department, have been aware of the problem posed by rainy weather, which causes a supply of very low-grade roughage, and of the problem involved in feeding existing low-grade feed during drought periods. Drought in crop-producing areas may not be as serious as unusually dry weather or grasshoppers in the range country, since crop residues exist in varying amounts in farming country. None of these residues, however, are available to a rancher driven out by lack of rain or by damage from insect pests. Research having a bearing on these problems is discussed here.

Stored reserves and winter range

Following considerable study based on many years of research, the New Mexico station has proposed a solution of these problems over a protracted period. It would solve the ever-menacing problem of forage shortage caused by drought through a method of balancing range reserves with animal production. At the South Dakota station and at others where hay can be made, investigations are under way to determine how long hay will last in storage.

The South Dakota station is studying the proper stage of maturity for cutting such hay for storage. It has found that the early hay gave the highest and most economical gains in wintering calves and that although hay stored for up to 3 years was not equal to freshly cut hay, it still was a highly acceptable feed. Of particular interest is the fact that hay stacked in 1945 showed no significant change in protein or carotene content during 4 to 5 years' storage.

The West Virginia station has shown that hay in well-made stacks can be stored without appreciably greater losses than when placed in a mow, but that care is needed in feeding in order to prevent excessive wasting of stack hay. Many stations have shown that it pays to have more than one year's forage supply in reserve, and this is becoming an accepted practice in many parts of the range country.

However, the experience of San Joaquin Valley ranchers raises a caution sign with respect to any such reserve. The California station showed that the abortions and blindness in cows in this drought-stricken area were due to a depletion of vitamin A reserves that resulted from long-time feeding of barley, hay, and other low-vitamin crop residues brought in from outside the area.

Research at the New Mexico station is of value because it has extended over a period of years of varying rainfall which has permitted an intensive study of the vitamin A content of range forage and its use in breeding beef cows on semidesert range. The conclusion was reached that in case of a prolonged drought or similar extreme conditions, a vitamin A deficiency might occur which would necessitate either the removal of livestock or full-scale feeding operations. Ordinarily, however, it has been established that a dangerously low winter blood carotene condition

was soon corrected by the appearance of early annuals and weeds in February and March.

The North Dakota station (coop. USDA) research has been concerned with the problem that arises when grazing is reduced on the rangelands during a period of drought and has made a careful botanical study of the forages on permanent meter square quadrates. During 1932–36 the grassland deteriorated partly from severe drought and partly because of heavy grazing. Under heavy grazing the typical mixed-grass prairie produced a preponderance of short grass, principally blue grama. Improvement resulted in 1937–41, indicating that when cattle were removed the grasslands tended to recover even though severely impaired by long-continued droughts. Latest information shows that some vegetation types yield up to four times as much as others, depending upon soil species and moisture. Greatest variability in production was apparent on the driest sites.

Increasing feed supply for emergencies

In the past heavy losses have occurred during drought periods in the range country unless cattle could be moved out to greener pasture. What research is doing to overcome this hazard is illustrated in an experiment at the Arizona station with the rather unorthodox practice of feeding salt with cottonseed meal as a supplement during extensive drought. Out of this study came an unqualified endorsement of this practice. Feed manufacturers are now making available in a pelleted or loose form, a ready-mixed product containing cottonseed meal, dehydrated alfalfa, molasses, and 30 percent of salt.

A commercial supplement for range cattle feed has become available as a result of experiments at the Oklahoma station which showed that urea, a nonprotein nitrogen, could be substituted for protein supplements such as cottonseed meal. The utilization by the animal of calcium and phosphorus was in no way affected, nor was there any appreciable effect on vitamin A storage when urea was fed. Urea ordinarily can be used for winter feeding, but it is especially valuable during prolonged drought.

Emphasis is now being placed on having a reserve pasture or range. For dry spells of short duration, some of the State experiment stations are suggesting "emergency pastures" of cereal grains, Sudans, or other forage material. At the Brazos River Field Laboratory of the Texas station a 22-acre oat pasture furnished good winter grazing for 85 steer calves for 94 days and for 88 cows and 30 calves for 21 days. The 85 steer calves made a total gain of 6,227 pounds, an average of 73 pounds per head, or an average daily gain of 0.7 pound. The gain per acre was 283 pounds. These were late calves that had just been weaned when they went on the oat pasture in November, averaging 335 pounds liveweight. The oats were growing so fast by November 27, that 88 cows and about 25 calves were added for 7 days. Eighty-eight cows, 3 bulls, and 35 baby calves were added in February for 14 days. These 22 acres are bordered on two sides by about 5

acres of Bermuda grass. The calves and cows bedded down on the Bermuda strips. On wet days, they grazed the oats just long enough to get a fill, then got back on the firm Bermuda grass areas. All the cattle were removed March 2, to go on test pastures. A stand of oats ample for several weeks' more grazing was cut in the dough stage early in May and baled.

The Arizona station showed that range area reserves can be made available by reducing cattle numbers on existing grazing lands, or by reclaiming lands presently overrun by plants such as mesquite, cholla, prickly pear, and burroweed. The station cleared out the undesirable growth and reseeded the land with Lehman lovegrass, slender grama, and Arizona cottongrass, and protected it from grazing until the stand was established. This land produced 878 pounds of air-dry forage per acre, roughly equivalent to the amount of hay consumed by a cow in a month. Meanwhile, the original open range produced only 112 pounds of forage, whereas protected land, cleared but not seeded, produced 371 pounds of air-dry forage.

Regrassing under dry-land conditions to increase resources has also been proved effective by the Colorado station. Lands seeded to cool season grasses, such as tall wheatgrass, produced 227 pounds of beef per acre in the first grazing year as compared with 30 pounds of beef per acre on comparable nearby native pastures. This additional production was valued at about $50 per acre for early season use under prices then prevailing. The cool season grasses are ready for grazing two to three weeks earlier than native grasses and may conserve stored feeding by as much as one-quarter ton of hay per cow per year.

The Nevada station has demonstrated the value of crested wheatgrass in range livestock production. During the period when it is necessary to make early use of the range, this seeded grass has been found particularly valuable because it provides good forage 2 weeks earlier than native grasses and thus makes it possible to defer grazing until the native grasses are ready for use. In a good stand, 2.89 acres of crested wheatgrass provided a month's grazing for one 2-year-old steer during late April to early June. A daily gain of as high as 2.82 pounds was observed during this time. Providing crested wheatgrass for early spring grazing will increase the value of summer gains by 2-year-old steers from $5 to $10 each. The utilization of this grass points a further way of increasing range resources.

Other experiment stations and the Department are engaged in similar research to increase the vegetation on deteriorated rangelands. The extent of improvement necessarily depends upon the degree of brush infestation, the quality and quantity of perennial grass remnants, the extent of soil depletion, the location of the range area, and prevailing weather.

Certain plants and byproducts may be harmful

During dry weather or periods of short or interim grazing animals eat many plants they would otherwise ignore. Frequently these plants may contain toxic materials resulting in heavy death

losses. Even excellent forage plants sometimes cause harm when eaten by pasturing stock.

As new crops are sought and introduced, animal husbandry departments determine whether they are safe as forage, or as byproducts after processing. The following examples show why it is necessary to know whether a crop may have possible harmful effects on livestock as a forage crop, not only under emergency conditions but also under common range and pasture conditions.

Even lush green pastures may be hazardous to any kind of stock. So-called grass tetany is not confined to any one region. It has been reported throughout the country and has been a particular problem to feeders who graze lambs on winter wheat. It is also found with cattle on new spring growth of excellent pastures. In some instances this trouble accompanies a low level of magnesium in the blood and acts rapidly on animals that have started pasturing on a particular feed. Frequently, it has been found that changing to dry forage immediately upon first losses will reduce the danger until the grazing becomes safe. Although the exact cause of grass tetany has not been established, the Texas, Mississippi, West Virginia, Oregon, and other stations have developed emergency measures against it. An eventual answer on control measures is looked for as research continues.

The South Dakota and Wyoming stations made important discoveries on selenium poisoning, reported in previous years. Out of this research came knowledge on indicator plants and the use of antidotes.

Losses, such as those from bracken poisoning, are still common and are under investigation at the Oregon and other stations. In Oregon the feared bracken has for decades invaded the denuded slopes of logged-off and fire-burned hills from the Cascade Mountains to the Pacific Ocean. The infestation not only keeps out plants that would provide good forage, but brings serious complications to animals (particularly horses) that eat it. Muscular incoordination, "fern staggers," results from eating hay containing some of this fern. The Oregon station discovered that laboratory animals fed samples of this fern came down with a severe nervous disorder. Efforts to counteract the trouble led to the experimental administration of vitamin B_1, or thiamine. The treated animals quickly recovered. The station found that the bracken possessed high antithiamine activity, removing the vitamin first by adsorption, after which it was destroyed by enzyme action. Although the research has established what causes the staggers, further studies are under way to learn how the bracken reacts on animals and how it can be eradicated through practical methods.

Western livestock men are becoming increasingly alarmed about *Halogeton glomeratus,* a poisonous plant found on the western ranges and eaten readily by cattle and sheep. When eaten in quantity, the oxalate in the plant combines with the calcium in the blood, depositing calcium salt crystals in the tissues and vital organs of the animal. The Nevada Experiment Station reports that it has found a relationship between liveweight, blood volume,

and amount of the plant eaten—150 grams (a little more than 5.25 ounces) will kill a 73-pound lamb. For a mature ewe weighing 121 to 150 pounds as much as 250 to 300 grams constituted the lethal dose. Sheep cannot be salvaged by any known calcium replacement treatments once they have eaten the plant in toxic amounts. Fortunately, the Nevada station reports that the plant oxalates are leached out by fall and winter rains or snows, making it comparatively harmless. In the summer and fall the only safeguard is to keep the sheep off the infested range.

The Oklahoma station is continuing its research on removing toxic materials from castor-bean oil meal. If they are successful in their efforts to remove these toxic agents, this meal may eventually become a desirable protein supplement.

Fescue seed is accompanied by a large volume of screenings. The feeding of screenings of this type to weanling calves and yearlings at the Oregon station resulted in death losses. The screenings kill cattle, cause sickness in sheep, and result in a nervous disorder in hogs. Close examination revealed that there is a high percentage of nematodes in the screenings; however, whether or not death resulted from the presence of the nematodes or from a toxic substance in the screenings still remains unknown. Through research of this nature fescue seed screenings may eventually become useable.

Not all substances in feedstuffs act as poisons or adversely affect blood minerals. Some may affect the glands of the body as reported by the California station, which discovered that rapeseed meal, a common ingredient in certain mixed stock feeds, contains a goiter-producing substance. This can be counteracted by the use of iodinated casein, a product of Missouri station research, but not by iodine itself. The California station also found a growth inhibitor in alfalfa but has successfully counteracted its effect through the use of cholesterol, an alcohol-like substance normally found in the blood of animals.

Research on Plant Wastes for Emergencies

For many years animal nutritionists have been trying to find crop materials that could be used as livestock feed during emergencies and to develop methods whereby low-grade roughages could be utilized. Since early days they have been concerned with the feeding value of materials such as straw, thistles, sugarcane bagasse, corncobs, and other high-cellulose-containing substances.

Since drought is generally not Nation-wide, some crops are usually available in surplus quantities in nonstricken areas. Several stations and the Department have under way research on high-cellulose materials and on various other crop wastes which could be used to combat drought. The possibility of utilizing vegetable and fruit wastes available in large commercial-growing areas as livestock feed is receiving increasing attention. The Department's Eastern Regional Laboratory at Philadelphia, Pa., and the Delaware station cooperated in experiments showing to

what extent wastes from vegetables such as broccoli, could be utilized by poultry, particularly broilers. The findings indicate that this waste is valuable not only to poultry but also to other classes of livestock. The research included assays for carotene (vitamin A). The Hawaii station showed that the feeding value of cull tomatoes, various waste fruits, and other products, such as those from banana, papaya, avocado, and taro, for swine feed was equal to about one-fourth to one-third of the value of the concentrates they replaced.

Even cull tangerines may be profitably utilized for hog feeding, as shown in trials at the Florida station. Where the volume of this cull fruit is large the cost of feed to produce 100 pounds of pork from hogs fed cull tangerines was only $7.12 plus whatever value might be placed on the tangerines. In the Florida trials it took a ton of tangerines and 159 pounds of a protein supplement to produce 100 pounds of pork.

As a result of the recent large surplus of potatoes, much interest has developed in their value in various forms for feeding purposes. In a 2-year feeding trial, the Minnesota station (coop. USDA) and the Red River Valley Potato Growers Association showed that raw potatoes can be fed successfully to beef cattle, bringing weight gains of 2 pounds per head per day. No cutting, slicing, chopping, or other treatment of the potatoes was necessary. Cattle were protected against choking by a rail fixed over the trough to keep the animals' heads down while feeding. These Minnesota station trials point to a practical and profitable method of marketing low-grade, cull, or surplus potatoes.

The Michigan station fed dehydrated potatoes to pigs. Although the cost of the potato flakes was too high to be practical, it was found that the dried material was equal to corn when fed at the rate of two parts of corn to one part of potato flakes. When more potato flakes were added to the ration the pigs ate more of the feed but developed digestive disturbances.

The North Carolina station (coop. USDA) made a satisfactory experimental silage from whole potatoes. Similar results were obtained by the Virginia station. In times of shortage of other feed, therefore, cull and surplus potatoes could be converted to cattle feed by ensiling.

Many soils in the Southern States are not suitable for growing corn but are excellent for growing sweetpotatoes which, according to the Alabama station, produce more calories per acre than does corn in Iowa. The Georgia, Louisiana, Arkansas, and Oklahoma stations have shown the value of sweetpotatoes for livestock feed. Louisiana research revealed that dehydrated sweetpotato feed was worth 90 percent of corn and that the sweetpotato-fed steers made the highest profit, with corn at $98 per ton and sweetpotatoes at $68. The Oklahoma station showed that dried sweetpotatoes have a feeding value that is 95 percent as high as the feeding value of corn on a dry-weight basis. The total cost of fuel and labor was about $12 per ton or 33 cents per equivalent corn bushel. Dried sweetpotatoes could be used as an emergency feed in drought-stricken areas.

The feeding of some high cellulose materials is possible, but it presents nutritional problems. Cottonseed hulls, long an excess waste product in the South, have been extensively investigated as a livestock feed by the South Carolina, North Carolina, Louisiana, Oklahoma, Florida, Mississippi, and Georgia stations. These tests have shown that properly utilized, cottonseed hulls can be fed to fattening steers by balancing protein and minerals (calcium) during 100- to 150-day fattening periods, although vitamin deficiencies may appear in this time, especially with younger animals. Lambs can safely be fed rations of hulls and cottonseed for only about 60 days.

Straw is high in lignin, a characteristic common to many of these celluloses, and in recent trials by the New York (Cornell) and Kentucky stations and the Department, it has been demonstrated that lignin is so undigested that it can be used as an index in determining the digestibility of other feed constituents. Straw is also lacking in minerals and vitamins, and therefore they must be supplied in any ration made up largely of straw. Past research has shown that straws from different sources have different feeding value, oat straw being much superior to rye straw. The present methods of analyzing for crude fiber do not separate out the lignin but the South Dakota station has devised an improved method by which most of the cellulose and lignin is retained in a single fraction. This should materially improve feed-evaluation studies.

Cellulose itself, or materials that are largely cellulose, have also been used in basic animal nutrition research. The New York (Cornell) station early indicated the biological significance of cellulose, lignin, and such carbohydrates. Several other stations are already attacking certain phases of the cellulose problem. This material is more easily handled by ruminant animals than by pigs, owing to the fermentations taking place in the rumen. For instance, the Nebraska station replaced part of the carbohydrate in a pig ration with a commercial cellulose product. At a replacement of 2.5, 5, and 10 percent, respectively, liveweight increase and feed per 100 pounds of gain were similar to the results obtained in a control group, but higher rates of cellulose depressed the rate of gain and of feed utilization. Carcass studies of animals fed cellulose revealed no differences from control animals attributable to feed.

Feeding value of corncobs

Certain phases of research on the nutritive value of corncobs have been recently undertaken; however, the grinding of whole ear corn for stock feed is a custom as old as our agriculture.

In 1943, the USDA Northern Regional Laboratory called attention to the composition, uses, and wide availability of corncobs. The Nebraska, Indiana, and Ohio stations have made numerous feeding trials with this product, and the Indiana station pointed out the value of molasses added to cob meal in fattening steers.

The Ohio fattening trials showed gains of better than 2 pounds per day for steers given a ration based on a very low grade hay, a protein supplement, and corn-and-cob meal with added cobs. The most recent series of three tests was conducted with 650- to 725-pound yearlings during 161- to 175-day feeding trials. Twenty pounds of ground cobs were added to 100 pounds of regular corn-and-cob meal (ground ear corn) and the steers were full fed. While the cob-fed steers made the satisfactory gain of 2.5 pounds per day, they were below the other lots in rate of gain, dressing percentage, and carcass grade. The station estimated, however, that the feeding of added cobs (218 pounds) saved 181 pounds of shelled corn and soybean meal per hundredweight gain, indicating a high replacement value for what is ordinarily a waste product.

The Indiana station points out that for economical wintering of steers more use should be made of the corncobs found in large volume on every Corn Belt farm. The station emphasizes that the cobs should be considered as roughage and not as substitute for corn or any other high-grade energy feed. The trials were conducted on calves from Colorado which by the time of the winter feeding period weighed 585 pounds. The experimental steer lots consumed slightly better than 14 pounds per day of corncobs, whereas the control lots ate 20 pounds daily of red clover-timothy hay. Steers on all the corncob rations outgained the hay-alone lot by from 0.3 to 0.5 pound per head per day. It took 22 pounds of hay to make 1 pound of winter gain, whereas it required only 10 to 12 pounds of corncobs, plus 3.8 to 2.7 pounds of a supplement. The cost of the winter gain was reduced by as much as 13 cents a pound through cob feeding. More than 200 cattlemen are now using cobs in winter feeding as a result of this research.

Wood molasses as livestock feed

The potential source of wood as animal feed is being studied cooperatively by the Department and a number of State experiment stations. The Forest Products Laboratory at Madison, Wis., is carrying on research on the production of wood sugar from wood wastes. The Oregon, Montana, and Mississippi stations have under way feeding trials to test the value of some of the wood byproducts as feed for dairy cattle, steers, sheep, and swine. The Wisconsin and Minnesota stations have also reported related research.

Although the Oregon study is not yet completed, observations have come out of it that may have a bearing on cattle feeding in future emergency periods. The addition of 2.7 pounds of Douglas fir wood molasses to the feed of wintering heifers increased the winter gain, but did not reduce hay consumption.

The project leaders feel that more research is needed before definite recommendations can be made on the basis of these trials. However, up to 20 percent of wood molasses in the ration of fattening lambs may be fed without ill effects to the lambs or the quality of the carcass. Lambs on this form of carbohydrate ate

more of the cellulose portions of the hay and would have consumed more roughage had it been available. This indicates the possibility of utilizing other low-quality roughages by adding Douglas fir wood molasses to stock feed. Pigs fed wood sugar molasses as 15 percent of the ration gained 1.36 pounds per day as compared to 1.63 pounds for the control lot. Because the cost of the other feeds was high, use of the wood molasses reduced the cost of the ration.

Wood molasses of a different origin replaced part of the corn in steer-fattening rations at the Mississippi station. In trials of 120 days' duration, 474-pound steers were fed a ration in which one-fourth of the corn was replaced by wood molasses. The corn-fed steers gained 1.95 pounds per day, and those receiving three-fourths corn and one-fourth wood molasses, 1.51 pounds per day. When compared on the basis of a three-fourths corn ration the use of molasses to make up the other one-fourth resulted in an increased gain of almost 1 pound per day in a short-time test.

Many questions remain to be answered before all is known about the feeding of wood molasses, which can become an important byproduct of the timber industry. For instance, the Oregon station is concerning itself with the question of what would happen by changing the acid reaction (pH) of the molasses. Questions like these explain why it is basically important to study what happens in the stomachs of ruminants. The effect of wood molasses and other new feeds on the microflora in the rumen must be fully understood before they can be given specific digestibility ratings.

The examples here recorded show the diversity of the rather extensive research programs that State experiment stations and the Department have under way on problems involved in increasing the availability of feedstuffs, particularly low-grade feedstuffs. Animal scientists are not yet sure of all the physiologic reactions that would result from the long-time use of each particular feed, or of a combination of the high-cellulose materials. Nothing is known on how these would affect reproduction, vision, and other physiological factors. But much more is known than during the drought of the 1930's, and this knowledge will be available if and when another drought should come.

DAIRY HUSBANDRY

The 1949 Report on the Agricultural Experiment Stations emphasized the great variety of research devoted to advancement of dairy farming. The wealth of dairy research progress reported during the current year shows that dairy research is continuing to make significant changes in the industry.

Physiology of Reproduction

A number of experiment stations have been studying the physiology of reproduction in dairy cows. One of the important find-

ings at the Illinois station is that spermatozoa ascend the reproductive tract of the cow in a matter of minutes. They found no difference in conception rate due to depositing the semen in the cervix, or in the body or horns of the uterus. The conception rate was highest when the cow was first bred 100 to 120 days after calving.

Wisconsin studies show that copulation hastens the time of ovulation following estrus.

The New York (Cornell) station reports as follows regarding heritability of fertility: "Under the present conditions and using non-returns as a measure of reproductive efficiency, selection for fertility in dairy cattle must be quite ineffective."

The Minnesota station has been using identical twins and triplets to study the effects of management and environment on growth and reproduction. The most striking results were obtained when two sets of triplet bulls were fed on three levels of energy intake. The two bulls, one from each set of triplets which were fed 70 percent of their calculated energy requirements, gained much slower than the other two sets. They came into sexual maturity later and produced less semen per ejaculate and a higher percentage of abnormal sperm. The pair of bulls which were fed 30 percent above calculated requirements were "normal" except that they showed a slightly above-normal total sperm number. The number of abnormal sperm was lowest with the best-fed bulls. At least six other stations are starting to use monozygous twins in their nutritional experiments.

Methods of increasing the livability of spermatozoa were studied. In cooperation with the New York Artificial Breeder's Coop., the Illinois station first tried to hydrolyze any peroxides which might develop in the semen by adding catalase. This method did not increase the conception rate. Then the researchers tried the procedure of partially diluting the fresh semen before cooling rather than vice versa. This technique resulted in a 9-percent higher conception rate in field trials.

The New York (Cornell) station continues to recommend whole eggs as being just as satisfactory as egg yolks for diluting bovine semen.

The Missouri station points to research carried on there indicating that sodium ions in the diluting media were detrimental to spermatozoa. To overcome some of this adverse effect they recommend adding glucose (for its osmotic effect) and sodium bicarbonate (as a buffer in place of sodium phosphate or sodium citrate).

In preliminary studies, the Nebraska station found that moderate amounts (0.13 mg. percent) of testosterone had no significant effect on livability of spermatozoa—larger amounts decreased survival. Thyroxine when added at the rate of 13 gamma percent increased conception rate about 5 percent.

Colorado station research workers noted that semen which shows exceptional longevity is also high in fructose. Attempts to raise the fructose content of the semen by injecting testosterone into the bull have been only moderate successful.

The New Jersey station after several years' study has concluded that there is no relationship between the hyaluronidase content of the semen and fertility.

Importance of good roughage in reproduction

Is soybean hay harmful to dairy cows? The Illinois station has found that when female rabbits are fed soybean hay the number of pregnancies are below normal, the litters are small, with a high fetal mortality. No trouble was experienced when alfalfa, timothy, or lespedeza hay was fed to litter mates. Similar trials with dairy cattle have not been reported.

The Indiana station reports that dairy cows on alfalfa-Ladino clover-bromegrass pasture produced 40.4 percent more milk than cows on alta-fescue-birdsfoot trefoil pasture. The former also gained 71 pounds per head for the season, whereas the cows on the alta-fescue-birdsfoot trefoil group lost 47 pounds. Not only did the alta-fescue lack palatability but it seemed to lack certain milk-producing qualities.

The iodine value or degree of unsaturation of milk fat varies rather erratically when cows are turned on pasture in the spring. The Iowa station showed that good pasture tended to increase the iodine value of milk fat an average of five units over winter feeding. These changes were largely dependent on changes in the oleic acid content of the fat. However, the stage of lactation exerts an even greater effect than pasture. When the same grain mixture was fed the iodine number dropped rapidly (average of 8 units) until about the fourth or fifth month of lactation and then rose slowly until the end of the lactation period.

The North Dakota station has been concerned with the number of reproductive failures and of dead calves dropped by dairy cattle after prolonged winter feeding. Research there showed that prairie hay put up in the heading stage contained, even after storage for almost a year, sufficient carotene to insure normal reproduction. In fact, the best prairie hay frequently contained more carotene the next spring than run-of-the-mow alfalfa. Sweetclover silage was one of the best feeds used to maintain high blood carotene values. Older cows in general had a higher level of carotene in their blood than young cows or heifers on the same ration. The addition of cobalt, iodine, or alpha-tocopherol (vitamin E) had no noticeable effect on the carotene levels of the blood. Blood proteins were not affected by the different rations fed.

The Wyoming station has been studying the value of alfalfa pellets and dehydrated alfalfa meal as sources of carotene for calves and cows. Their results to date would indicate that the advertised beneficial effect of alfalfa pellets for dairy cattle may be overstated. Carotene analysis of alfalfa pellets showed rapid deterioration as the winter advanced. By January the carotene content of alfalfa pellets and dehydrated alfalfa meal had a value equal to that in the alfalfa hay fed in the outside hay bunk.

Oklahoma has tried to determine the value of ground alfalfa when added to a concentrate mixture fed with alfalfa hay. These

experiments showed that each 100 pounds of ground alfalfa hay was equal in feeding value to 66 pounds of concentrates.

Dairy cows, according to the Hawaii station, can consume up to 16 percent crude fiber in their ration without depressing their milk production. With an intake above 16 percent fiber the cow must be fed additional nutrients to "digest" the fiber.

Physiology of Dairy Animals

Dairy scientists are fast learning the role of the rumen flora in the digestive process. The Wisconsin station reports that a very substantial portion of the nutrients actually utilized by the cow are of microbiological origin (bacteria or protozoa). The predominant bacterial flora in the rumen of cows on a normal grain and roughage ration consists of gram-positive, anerobic, rod-shaped bacterium present usually in numbers between 10 and 100 billion per gram of wet rumen contents. Remarkable similarity, both quantitative and qualitative, was shown in the bacterial flora of the rumen of cows on identical rations. That changes in diet do have a very important bearing on milk secretion was discovered in the course of these trials. Under certain conditions when the amount of roughage in the diet was reduced to a very low level the cows produced an abnormally low-fat-content milk. Although large amounts of roughage in the cow's diet supposedly do not raise milk production above her inherited capacity, plenty of good roughage is necessary for maximum milk production.

In 26 paired and 10 triplet feeding experiments with calves the Oregon station found that 0.1 percent total sulfur in the ration is about the lowest quantity an animal can consume and still utilize nitrogen efficiently in the rumen. The addition of 0.5 percent of methionine or 1 percent of sodium sulfate to the ration gave little or no beneficial effect. This experiment indicates that a ruminant utilizes sulfur very efficiently and possibly uses the limited amounts of the sulfur in its body over and over.

For almost 30 years an Illinois dairy specialist has been consistently studying production records in an effort to interpret variations in production between lactations of the same and related animals. The study has resulted in some 35 technical publications and the development of innumerable fundamental concepts regarding the physiology of milk secretion. His formula for converting records of milk with different fat contents and energy values to a common denominator is used almost universally in experimental projects where the production of different animals must be compared.

In his concluding report this leader presents formulas to be used in comparing records when the length of lactation, time calf was carried, and the age of cow, vary. One of the most important conclusions of this report is that age and liveweight affect yield about equally. In other words, the amount of fat-corrected milk (FCM) a heifer produces in a year depends about

equally on her age and size, assuming that all factors except food intake remain constant. The results of this one project have done as much as any one study could hope to do in changing dairy husbandry from an art to a science.

Effect of sulfa drugs on dairy cows

The Pennsylvania station undertook experiments to learn whether sulfonamides, used widely as therapeutics, cause any ill effects on the metabolism of dairy animals. They report that sulfamerazine, sulfathiazole, and sulfathaladine produced no detrimental effects on vitamin A and carotene metabolism. Sulfaquinoxaline, when administered in therapeutic doses, proved harmless so far as hemoglobin or bilirubin formation is concerned.

Thyroprotein and milk production

Tennessee has had five cows on a ration supplemented with thyroprotein for two lactations. Their results indicate that approximately 10 percent higher production may be secured during the latter half of lactation by feeding thyroprotein (Protamone), but the extra production secured was not as economical as when the cows were fed normally. Milk production was stimulated above normal for about 8 weeks. Weight loss occurred in spite of increased grain allowances but weights were normal by the time the cows went dry.

Method sought for measuring glandular secretion

Animal breeders have no way of measuring how much of the different hormones the glands of individual animals are able to produce. If such a way were available, it would be possible to estimate in advance and at an early age the productivity of an individual cow. The Missouri station is endeavoring to develop a method of determining the hormone-producing capacity of the glands of an individual animal without affecting the health of the animal. In this research an attempt is being made to measure a natural hormone (progesterone) secreted by the yellow mass (corpus luteum) in the ovary during early pregnancy. The technique used consists in removing the potential natural sources of the hormones and then measuring the quantity of purified hormone the particular cow needs to keep from losing her calf. By a slightly different technique, the station is also trying to establish a method for estimating the secretion rate of the thyroid gland. A solution of the problem being studied in this research should contribute materially to future practical improvement of dairy animals and milk production.

Scientists at a number of stations have brought nonpregnant heifers into milk with injections of stilbestrol. Certain undesirable "side effects" of this treatment—the tendency it develops in some animals to remain constantly in heat, for instance—have prevented its use except for experimental purposes. Now Michigan physiologists have discovered that the simultaneous use of progesterone and stilbestrol prevent the bad side effects and

possibly increase milk production. Although the Michigan workers are not yet recommending their technique for practical use, a long step forward apparently has been made. The station has also tried rubbing stilbestrol onto the udders of heifers which have just freshened in the hope of relieving congestion by stimulating blood circulation. The results with eight heifers have been very encouraging. The station used 200 milligrams of diethylstilbestrol dissolved in 10 milliliters of corn oil on each heifer.

The Missouri station has reported more favorable results with thyroprotein when estrogen or some derivative of diethylstilbestrol was administered to goats along with the thyroprotein. Results suggest an increased vitamin B_{12} requirement when thyroprotein is fed.

Milking machines can ruin udders

The Pennsylvania station carried on an experiment to find out what happens to the udder if the milking machine is left on too long. Each cow was milked twice a day. During milking a teat cup was regularly removed from one teat at the end of 5 minutes, from a second teat in 10 minutes, from a third teat in 15 minutes, and from the remaining teat at the end of 20 minutes. After 30 days the cows were slaughtered and the lining of the teats was examined. The mucous membrane of the teats to which the milking machine had been attached for 15 minutes or longer showed signs of acute inflamation near the base of the teat; a few of the transverse folds were also inflamed. White cells typical of a pathological condition predominated in the milk from the most inflamed quarters. The experiment clearly proved the advantage of fast milking.

Cows enjoy cool weather

Dairy husbandmen at the Louisiana station tried to put into practice recent information regarding the harmful effect of high temperatures on milk secretion. They prepared a sprinkling device to which the cows could go at will when the temperature became uncomfortably high. Although the cows frequently used the sprinkler to cool off, milk production did not show a significant increase for either Holsteins or Jerseys that used the sprinklers. Respiration rates were considerably lower for those cows using the shower, indicating that they were much more comfortable.

The Missouri station (coop. USDA) is continuing its research on the physiological reactions of cows to changes in temperature. Cows are most comfortable between 40° and 60° F. As the temperature goes above 75°, the rectal temperature of European cattle (Jerseys and Holsteins) tends to rise, whereas that of Indian cattle (Brahman) does not go up until the environmental temperature is around 95°. The pulse rate of European cattle starts up at 85°, in Indian cattle at 95°. Respiration rate begins to accelerate in European cattle above 65°, whereas Indian cattle still breathe regularly at 80°. The Missouri station suggests that

the rate of heat dissipation depends more on the surface of the animal than it does on the animal's weight. Hence, animals with many folds of loose skin on their bodies can stand heat with less discomfort up to about 95°. The inability of cows to keep comfortable by evaporation of moisture through the lungs or from the skin means they must use energy to keep cool. Consequently, less energy is available for milk production in hot weather. This drop in milk production is further reduced by a decline in feed consumption which probably represents another method used instinctively by the cow to cut down heat production.

Many stations have avoided running carefully controlled digestion trials because of the cost, the need of especially trained personnel, and the difficulty of interpreting the results in some instances. The New York (Cornell) station discovered a somewhat simpler technique by which coefficients of digestion can be determined from one sample of feces rather than from a composite sample collected over probably a 10-day period. This is done by determining the level of characteristic pigments (chromogens) in the individual samples of feces.

Studies on calf nutrition

The Ohio station tried to determine at which age a calf becomes a true ruminant and how its digestive processes are changed at that time. They found that the ratio of milk to grain and roughage fed would have an influence on the type of organisms which would grow in the rumen. When the rate of alfalfa feeding was increased, cellulose digestion was markedly reduced. However, once the right flora was established in the rumen, a high roughage diet became practical. Some of the organisms which thrive in the rumen are readily digested in the juices secreted in the fourth stomach. Others pass through the animal undigested.

Using the fat content of livers as the main criterion, scientists at the North Carolina station have sought to learn the choline requirements of calves fed synthetic diets. The only clue to the reason for the failure of choline to prevent fatty livers was discovered in an experiment in raising kid goats on synthetic rations. When starch was substituted for glucose the kids did not develop fatty livers. But for some unexplainable reason the calves with the normal livers grew more slowly than those fed glucose.

Confirming this latter finding, the Michigan station has reported that young calves do not thrive on starch where it is the principal source of energy in diets. The station recommends lactose as the best carbohydrate to feed and suggests dry whey as a commercial source of lactose where a calf starter is being prepared.

The New Hampshire station found that the digestibility of the protein in the ration of vitamin D deficient calves was 3.5 percent lower than in that of the control calves. Paradoxically, in 33 metabolism trials with the deficient calves the metabolic rate was significantly higher.

Young calves need an external source of riboflavin until the rumen begins to function. The Indiana station found that when calves are fed whole milk containing about 10 milligrams of ribo-

flavin daily, about 1.4 milligrams appear in the urine. On an inadequate riboflavin diet the level of this vitamin in the calves' urine dropped to 0.1 milligram or less per day. Supporting previous findings on the symptoms caused by feeding a low riboflavin diet, reported by the Indiana and Illinois stations, the Ohio station established that the minimum daily riboflavin requirement for a very young calf is between 35 and 45 micrograms per kilogram of body weight.

The California station as a result of trials with radioactive phosphorus found little difference in the distribution of the phosphorous isotope in the calves' tissues when they were given phosphorus in the organic form as milk casein, were fed inorganic phosphate, or inorganic phosphate was injected directly into the blood stream.

MILK AND MILK PRODUCTS

Quality Constantly Being Improved

Additional results are being reported on the progress made by a number of stations to overcome oxidized or "cardboard" flavor in processed milk products. Some harmless antioxidants are sought. Oat flour, tocopherol, and certain other materials have been used experimentally as antioxidants for a number of years. During the year the Massachusetts station announced that corn flour was equally as effective as oat flour. However, wheat, barley, rye, and rice flours possessed little value for this purpose.

Cocoa flour, especially when there was a slight trace of copper present, proved to be the best all-round antioxidant for milk, ice cream, or cream before it is pasteurized and churned into butter. It was equal to ascorbic acid and nearly equal to tocopherol, but was less effective than gallic acid, propyl gallate, NDGA (nordihydroguaiaretic acid), coffeic acid, and tannic acid. However, all of the antioxidants just mentioned except cocoa flour imparted a foreign flavor to the milk. The cocoa inhibitor was used at a concentration of 0.05 percent. It was even quite effective for treating paper milk bottle stock.

The New York (Cornell) experiment station showed that the tocopherol content of the milk and body tissues can be increased by increasing the tocopherol content of the cow's diet. In other words, feed the cow so she will produce what the trade calls a more stable product.

The Illinois station obtained quantitative data on the effect of high-temperature, short-time pasteurization on the precipitation of calcium, magnesium, and phosphorus and to the denaturation of albumin and globulin in milk.

Wisconsin station chemists have redetermined the nonprotein nitrogen fractions in milk. Although these compounds make up a small fraction of the milk solids it is important to know what part each plays in the processing and keeping of dairy products. The Wisconsin station has also made a very thorough analysis of the minor constituents including the naturally occurring salts in milk.

New milk preservative for butterfat

The milk of an individual cow, or of a herd, loses about 0.05 percent of its fat content overnight as a result of the splitting of the fat by the natural enzymes (lipases) in the milk. The Maine experiment station recently found that acetophenone, used either alone or in combination with other preservatives, extends to 15 days the period within which composite samples of milk can be preserved for subsequent testing.

Using detergents economically

After successfully coping with the problem of producing rich-flavored cheese from pasteurized milk the cheese maker was confronted with the deleterious effects of small amounts of the new cleansing agents left on milking utensils by careless dairymen or which had been intentionally added to control bacterial growth. As little as 10 p. p. m. of quaternary ammonium compounds will cause a delay of 45 to 60 minutes in the milling time of cheese. This year the Oregon station published a simple method by which the presence of these compounds can be detected in milk. With slight modifications the procedure may be used to determine the concentration of quaternary ammonium compounds in detergents. Use of such a method would insure a solution strong enough to sanitize dairy utensils without waste of cleansing materials.

Antibiotics for mastitis curatives affects cheese making

The dairy journals are full of reports showing that batch after batch of cheese has been ruined by small amounts of mastitis curatives (antibiotics) in the milk. The Vermont station has found that milk from cows treated with penicillin or a mixture of penicillin and streptomycin will not ripen normally when starter is added unless treatment is discontinued at least 2 days previous to the addition of the starter. Residual amounts of aureomycin in the milk inhibited the action of cheese starter for 3 to 4 days after treatment was discontinued. After 10 months' curing cheese made from milk containing aureomycin had weak body and extremely flat flavor.

The Idaho station also tested the effects of a number of the sulfa drugs in making cheese. Sulfamerazine and similar compounds did not kill the lactic acid bacteria in the starter but they stopped the growth of these organisms for 6 to 8 hours. Such a delay interferes with the manufacturing process and usually lowers the quality of the cheese. At present no practical method is known of destroying or inactivating these antibiotics occurring in the milk of cows recently treated for mastitis. Pasteurization, for instance, does not affect most antibiotics. The simplest solution to the problem would be for farmers not to market milk from treated cows until 4 to 6 days after treatment had ceased. To avoid using milk on which this precaution is not observed the milk-receiving plant should have a simple test that can be used on all milk as it is received.

Because of the difficulty of detecting antibiotics in milk, dairy technologists are attempting to develop strains of starter organisms that will resist small amounts of antibiotics. Although milk containing any antibiotic should not be sold for human consumption, the amount of antibiotics usually present is so low as to be harmless from a health standpoint. However, even minute amounts of penicillin and similar drugs seriously interfere with the manufacture of cheese. The Florida station has added penicillin experimentally to evaporated and condensed whole and skim milk as well as nonfat dry milk to see if antibiotics could be used to protect dairy products from spoilage. In most of the products some penicillin was still active after 10 days' storage. In nonfat dry milk there was no detectable loss of penicillin potency during a period of 10 weeks at room temperature. Oregon has obtained a proteolytic extract from filberts which shortens the ripening period and improves flavor when used in the manufacture of cheddar cheese.

Still another problem that has become increasingly serious in recent years is the prevalence of a bacteriophage which destroys or weakens lactic starter cultures used in the manufacture of cheese. The Oregon station has developed several strains of lactic starters that are resistant to the phages encountered in certain cheese factories in Oregon. The station has also compared the efficiency against phages of various sanitizing agents. Their results indicate that hypochlorite solutions are superior to quarternary ammonium compounds. The phages that destroy lactic-acid-producing bacteria also destroy the bacteria that produce certain so-called aroma compounds. Failure of a culture to actively produce either lactic acid or the aroma compounds results in a serious loss in quality of cheese. In some cases the batch of cultured milk is a complete loss.

The Pennsylvania station has secured evidence that the characteristic odor and biting taste of cheddar cheese is caused by three ketone compounds (the ketones, 2-pentanone, 2-heptanone, and 2-nonanone).

The Wisconsin station has found that applying ultrasonic waves to cheddar cheese accelerates the ripening process. This treatment altered the normal sequence of bacterial development and produced abnormally high populations of three types of organisms (streptococci, micrococci, and lactobacilli). Two of the amino acids (glutamic acid and leucine), which are associated with cheese flavor, were found in increased amounts. In simple-system studies the action of ultrasonic sound waves was shown to increase the pH, to split lactates and citrates, and to produce flavor compounds from organic acids, salts, and butterfat.

Considerable interest is shown by experiment stations in special types of cheese. At the Pennsylvania station a test of Italian-type grating cheeses has been completed. The Minnesota station has developed a white mutant of *Penicillium roqueforti* which produces a typical Roquefort flavor in a much shorter time and a creamier body than the normal green parent. The Wisconsin station is testing the commercial value of white strains of *P.*

roqueforti. These white strains produce flavors and possess growth rates similar to those of green strains. They require less iron than the green strains which raises the question of whether a better blue cheese (common Roquefort) can be made by adding iron to the milk.

Research with blue cheese was also continued. The Iowa station reports that when calcium chloride is added to pasteurized homogenized milk in making blue cheese the renneting time is shortened; the curd is firmer and more elastic; and the cured cheese has a more open texture. No reports are available on the consumer acceptance of these changes.

The Montana station is engaged in research that will give a more widely accepted flavor to cottage cheese, thereby increasing its consumption. The station discovered that adding 0.008 to 0.05 percent of citric acid to the milk before inoculation improved the cheese flavor. The North Carolina station learned that the bacteria used in preparing cultured buttermilk do not destroy the vitamins present in the milk. However, adding sodium citrate to the milk prior to culturing to enhance flavor production will lower the riboflavin content. This discovery may have some bearing on the use of citric acid in the manufacturing of cheese.

Cream and fat

Cows fed a considerable quantity of cottonseed meal produce a gummy butter. Analytical data from the Texas station indicate that such butter contains higher percentages of long-chain fatty acids and lower amounts of short-chain fatty acids. By adding grain sorghum silage to a ration containing either hydraulic or solvent-extracted cottonseed meal the station was able to produce a butter which exhibited very little gumminess.

According to the North Dakota station the addition of biacetyl to salted butter in concentrations of 0.04 percent effectively prevented development of putrefactive flavor in butter stored for 120 hours at 5° C. or 24 hours at 21° by keeping down the growth of the responsible organism (*Pseudomonas putrefaciens*).

The Oklahoma station recommends the addition of 10 percent salt to the nonfat portion of the cream when it must be held several days on the farm without refrigeration. Butter from unsalted cream in samples held for 7 days scored 33.6, whereas butter made from the same cream with a 10-percent concentration of salt had an average score of 37.4.

At the Florida station the use of soft water only in ice cream mixes to balance the nonfat dry-milk solids and the heavy cream reduced the freezing time of gelatin-stabilized ice cream by slightly more than 11 percent and improved its texture. Mixes stabilized with sodium alginate or CMC (sodium carboxymethyl cellulose) whipped slightly faster when hard water was used.

Condensed and dry milk

The Washington station has been trying to improve the keeping quality and usability of spray-dried whole milk. Preheating

milk to at least 140° F. for 20 minutes left no rancidity in the fresh powder and none developed during storage of the powder at 45° or 85° for a year when sealed from moisture. At high humidity the preheating had to be above 140° to prevent rancidity from developing. However, whole milk powder stored at 85° rapidly loses the desirable wetting qualities, lowering its solubility.

When nonfat dry-milk solids were used in baking bread at the Washington station, the loaves were found to be relatively small when the amount of undenatured whey protein nitrogen was near 6 mg. per gram of nonfat milk solids. Maximum loaf volumes were secured when this value was reduced by heat treatment to 2 mg. or less before drying of the milk.

Better milk powder with new drier

After 10 years of fundamental research, the Minnesota station has developed a model milk drier that overcomes previous objections with respect to flavor in the manufacture of dried milk powder. In addition, the new drier permits the packing of from 25 to 50 pounds more powder per barrel. Compared with some conventional driers, a capacity-size unit of 800 pounds per hour can, due to this firmer packing, save 20 barrels and liners per day; this unit, working at full capacity throughout the year, can save a plant up to $16,000 a year.

The drier operates on a new principle which the Minnesota station terms an "air straightening device." This prevents heat damage while the milk is drying. It prevents eddy currents of hot air from striking partially dried particles of milk powder. A secondary filter prevents even the smallest particles from escaping in the exhaust air.

Sanitation

Methods of cleaning and sanitizing dairy equipment have undergone many changes in the past few years. The most recent cleaning products to be tried are organic "chelating" (combining) agents which increase the efficiency of commonly used detergents. The Michigan station has found that ethylene diamine tetra sodium acetate, used in combination with a wetting agent and condensed phosphate, gave the highest detergency values of any of the products tried.

Research on quaternary ammonium compounds at the Oregon station has already been referred to in the paragraphs on manufacture of cheese. The Massachusetts station has developed a technique for evaluating the sanitizing properties of quaternary ammonium compounds. The station claims its method gives a truer picture of the germicidal potency of a solution under actual working conditions than is given by phenol coefficient values. Although quaternary germicides have advantages over chlorine sanitizers they also have some limitations, such as the adverse effect when they are used with hard water. The Massachusetts station reports the interfering cations which cause this difficulty, arranged in order of decreasing importance, are aluminum, ferric,

cupric, zinc, nickel, manganese, barium, ferrous, magnesium, calcium, and the monovalent cations.

The Wisconsin station compared types and numbers of bacteria found in the pooled milk from the respective herds in each of two open or shed-type barns and a stanchion barn. Periodically, samples from each quarter of each cow were also tested. Throughout the winter the bacterial plate counts on the milk from cows kept in the shed barns were about twice those of milk from cows kept in stanchions. This difference was not due to filth adhering to the animal's coats—a study of the organisms (cocci) indicated they came from the interior of the udders. No explanation for this condition, which may have considerable ultimate importance, has so far been suggested.

RESEARCH IN POULTRY INDUSTRY

Breeding Better Poultry

Poultry breeders have made noteworthy progress in the development of standard-bred poultry, many flocks averaging annually 200 or more eggs per bird of reasonable quality and size. Beyond this, little improvement has been made in recent years in breeding for high viability, market quality, and economy of meat and egg production. A re-examination of present breeding practices is needed so that more effective methods of selecting animals and better systems of breeding may be established. Such research would include the development, testing, and evaluation of breeding methods and use of inbred strains for the production of hybrids, crossing standard breeds, and a more rigorous application of family selection within standard-bred strains, but the problems involved in such a program are too complex and expensive to be undertaken by a single research institution. Therefore, the united attack of a number of States in close cooperation with the Department, now being realized under the regional research program authorized in the Research and Marketing Act of 1946, appears to be the logical way to reach a sound and more rapid solution of problems that are too hard to solve by individual breeders and institutions.

Regional research in North Central States

The effectiveness of the cooperative regional approach in research is well illustrated in the poultry breeding project undertaken by North Central experiment stations in close cooperation with the Bureau of Animal Industry. A total of 58 inbred lines of chickens representing the White Plymouth Rock, Australorp, Langshan, Ancona, Brown Leghorn, Rhode Island Red, White Leghorn, New Hampshire, and Crossbred, have already been developed by the various stations, and 11 new inbreds are in the process of development. The value of these inbreds for the production of hybrids is being determined under uniform conditions at the central testing station maintained in conjunction with the Indiana station and Purdue University. Facilities there are

also available for testing inbred lines developed in other regions. Preliminary evaluations of many of the inbreds have been made throughout the region by means of two-way, three-way, and four-way crossings among the lines. An ingenious shortcut in the breeding procedure is now being taken, one that can accomplish in a single year what would ordinarily require about 20 years of effort. Using the very prolific fruitfly as a test animal, instead of the chicken, the relative effectiveness of various systems of breeding according to egg size and production, is being determined. The results obtained from such a test are to be applied to the chicken, thus circumventing all the intermediate, time-consuming steps.

Regional breeding for improved Southern chickens

A regional poultry study, also in cooperation with the Department, is being conducted among the 10 southern State experiment stations. Inbred lines of White Leghorn, New Hampshire, Rhode Island Red, Barred Plymouth Rock, and White Rock are being developed, and some were tested in 1950 at the central testing station. Superior meat-type chickens with broad breasts have resulted from crosses of New Hampshires and Cornish birds, and highly productive birds are being produced whose sex can be determined at hatching time by down-color differences. In some of the heavy breeds considerable progress has been made in converting the strains from late to early feathering. The production, size, fertility, and hatchability of eggs have been improved in both New Hampshires and White Rocks, and resistance to coccidiosis is being developed. New Hampshire hens which lay more than 300 eggs annually have been produced at one station.

Regional turkey studies in the West

Research on the breeding of turkeys is being conducted under the regional approach by six of the western State experiment stations in collaboration with the Department. Differences were found among turkey males with respect to age at sexual maturity, pauses in sperm production, and persistency of sperm production. Sterility in toms seems to be recessive to normal potency. Family differences have been observed in the volume, density, and the fertilizing capacity of semen, and its duration of fertility in the hen following insemination. Fertility of hens generally remained high when insemination was made at 2-week intervals. The minimum optimum dosage of semen is 1/40 cubic centimeter, which provides 90 to 95 percent fertility 2 days after insemination.

Feather pigment as tool in breeding

The Indiana station conducted a fundamental study on the nature of gene action as revealed through feather pigmentation. When gene action is more fully understood it may be possible to substitute missing physiologically active substances and bring

about a desirable genetic condition even in the absence of the necessary or desirable gene complexes. This would make it possible to produce superior poultry without waiting for the results of the present tedious but seemingly necessary steps in the breeding programs.

As a result of the Indiana research, the pigments of the cushion and saddle feathers of Rhode Island Red chickens have been separated according to color, and four different pigments have been isolated. These four pigments have been divided into two general groups of two purple and two brown pigments each, on the basis of their behavior, when analyzed by chromatography (a new chemical method of separation); their light-absorption properties; and their color change in relation to the acid-base balance and iron content. The two purple pigments are assumed to be iron phenolic compounds.

Red and buff feather pigments from the jungle fowl (progenitor of all chickens), seven varieties of domestic fowl, two varieties of turkeys, bobwhite quail, and the red hair from human beings and dogs, all contained the same red-purple and brown pigments. However, observations indicate that quantitative differences in total feather pigment and the relative amounts of pigments within and between species may account for differences in observed color of feathers and hair. The Brown I pigment fraction represents the bulk of the color in all breeds and species whenever pigment is present.

The characteristics of pigment granules from feathers of the Black Australorp, Blue Andalusian, Rhode Island Red, and Buff Orpington have been studied under an electron microscope. Photomicrographs and measurements of the granules have been made. Pigment granules from black feathers were found to be mostly rod-shaped, but a few granules were elliptical or round. Pigment granules from blue feathers, on the other hand, were mostly elliptical. Both types of granules exhibited an apparent fiber-like internal structure.

Poultry Nutrition

Rapid strides are being made by State experiment stations in several fields of poultry nutrition. New scientific devices, like radioisotopes, and a vast amount of new knowledge about growth factors and antibiotics, have opened up a wide horizon of research activities that are bound to bring great changes in poultry production—the Nation's fourth largest farming enterprise.

Growth factors for chicks and poults

The recent discovery of the important growth-promotion element in feed, vitamin B_{12}, has stimulated poultry nutrition research by the experiment stations and the Department. A large volume of information on such subjects as "Vitamin B_{12}," "The Animal Protein Factor," and "Unknown Growth Factors," has been published in the past year. Contributions have been made by the Maryland, New York (Cornell), Colorado, Iowa, Wash-

ington, Wisconsin, Idaho, Minnesota, Michigan, Texas, and Ohio stations as well as the Department, and by some other stations already referred to in the *Report on the Agricultural Experiment Stations, 1949*. The Ohio station's findings regarding important dietary factors in built-up litter, now believed to be riboflavin and the animal protein factor, were given in the 1948 report. During the past year further advances along these lines were made, especially in the applications of the original findings to practical feeding operations.

Several forms of vitamin B_{12}

The value of independent research by a number of institutions is demonstrated by sometimes seemingly conflicting results. Differences in findings promote research that helps bring the important facts to light. For example, the Washington station found that vitamin B_{12} activity of a feed supplement for chicks is not necessarily correlated with vitamin B_{12} content. There are forms of vitamin B_{12} in some supplements that are stable to an alkaline autoclaving treatment that ordinarily destroys vitamin B_{12}. Although vitamin B_{12} appears to be the main, if not the only, growth factor supplied to corn-soybean poultry rations by fish meal and meal and has been markedly effective in improving hatchability under conditions in which animal protein concentrates have been effective in past experiments, nevertheless some of the commercial "animal protein factor supplements" have proved to be far more effective in promoting growth of both chicks and turkeys than either pure vitamin B_{12} or fish meal.

In studying growth-stimulating factors in fractions obtained from a liver preparation, the New York (Cornell) station found indications of four unidentified substances which promote rapid early growth in chicks. By using refined methods of determining nutrients in feed through growth of micro-organisms, usually referred to technically as microbiological assay, the station obtained evidence that two of the unidentified factors were different forms of vitamin B_{12}, whereas the other two substances were not identical with any of the known vitamins.

Antibiotics as growth promoters

In the light of basic findings on growth-promoting substances and on the apparent role which some of the soil organisms play in promoting growth, the question has arisen: Do vitamin B_{12} concentrates sometimes contain other growth factors? Vitamin B_{12} concentrates are prepared by manufacturing chemists, from mold used in the preparation of antibiotics—those wonderful, natural germ-destroying agents like penicillin, aureomycin, streptomycin, and terramycin. Some of the vitamin B_{12} concentrates were found to contain small quantities of aureomycin, a fact which led research men to investigate the growth-promoting possibilities of this antibiotic.

The Washington station presents evidence that the added growth-promoting properties of some "animal protein factor supplements" have been due to the presence of the antibiotics, strep-

tomycin, terramycin, and aureomycin, all of which appear to have about equal growth-promoting properties when given to turkeys. Aureomycin is likewise reported to have caused rapid growth of chicks at the Michigan station.

Both aureomycin and streptomycin are helping Texas poultrymen to go into mass production of broilers and fryers on a "3-10-9" schedule (the rearing of a 3-pound broiler in 10 weeks on 9 pounds of feed), and to convert 3 pounds of feed into a pound of chicken. A year ago these producers were raising a 3-pound broiler in 12 weeks on 12 pounds of feed—a conversion of 4 pounds of feed into a pound of bird. This remarkable change in feeding practice provides housewives with younger, more tender birds. At the same time it gives the producers an extra profit of $7,000,000 annually. It is the result of a new ration developed by the Texas station, a ration that includes vitamin B_{12}, aureomycin, and streptomycin.

In the research with turkeys, the Texas station found that the addition of only vitamin B_{12} or of only 4 percent of fish solubles to an "all-plant" ration did not result in any increase in weight at 24 weeks of age over similar birds fed only the basal ration. However, an additional growth response of about 0.75 pound per bird was obtained by adding to the ration either the antibiotics, streptomycin and penicillin, or animal protein factor concentrates containing antibiotics. Best results were obtained when the feed contained a mixture of antibiotics and vitamin B_{12}. The addition of this mixture produced an increase in weight of 20 to 25 percent at 8 weeks and required 20 percent less feed per pound of gain.

Antibiotic apparently not a nutrient

In order to substantiate its theory that antibiotics act on the intestinal bacteria of the chicks to give added growth, the Michigan station compared the results of administering aureomycin to the birds through the feed and by inoculations. Although the injections did not stimulate growth reaction, the feeding of the material to the birds nearly doubled their growth in some cases. These results indicate that the effect of the aureomycin is an indirect one whereby the flora of the digestive tract is improved, thus encouraging synthesis of nutrients or permitting more complete utilization of those in the diet. If the antibiotic were another nutrient and thereby could be assimilated, it should promote growth when injected into the tissues as effectively as when administered orally.

Caution on Use of Antibiotics in Feeds.—**From the West Coast comes a warning regarding the use of antibiotics in feed until further research has been done on them. Foreseeing their possible widespread use in the poultry industry, California scientists recently met to discuss some of the implications of using antibiotics in rations. It was the consensus of this group that as yet there is insufficient information concerning the use of antibiotics to warrant a general recommendation of their use as feedstuffs. Too little is known concerning their action to rule out certain potential hazards to the poultry industry. The group**

agreed that if the antibiotics themselves produce the observed growth-effect simply by reducing the numbers of competing micro-organisms in the intestinal tract, it is possible that resistant micro-organisms may in time develop and thus nullify the effect of the antibiotic.

It is also possible that the meat or eggs from birds fed antibiotics might contain these antibiotics in amounts sufficient to reduce the usefulness of antibiotics in the treatment of human diseases. Inasmuch, however, as the antibiotics are rapidly excreted and are unstable in solution, this seems unlikely. Nevertheless, the problem demands investigation by public health officials.

If some breakdown products of antibiotics provide vitamin-like nutrients which promote rapid growth, the antibiotics might be treated in such a way that their antibiotic activity would be destroyed, but their growth activity retained. Such treatment would eliminate the difficulties just mentioned. Extensive trials of antibiotics as feedstuffs, in progress at various experiment stations, should ultimately solve these problems.

Other factors awaiting investigation

Discovery of vitamin B_{12} and of the fact that it exists in several forms, also of the growth-promoting properties of antibiotics, does not conclude this line of research. There still are some fundamental phenomena that are not understood. Some of these unknown factors call for investigation, as revealed by the favorable effect on growth of an arsenical, 3-nitro 4-hydroxyphenyl arsonic acid, developed for the treatment of coccidiosis, and of the antiscurvy vitamin, ascorbic acid (vitamin C), formerly considered not needed for birds but now known to give additional growth response when added in large amounts to rations fortified with vitamin B_{12} and aureomycin.

Radioactive isotopes in poultry nutrition

Radioactive isotopes are now coming into widespread scientific use for the study of all living processes. Until recently they have not been used extensively in the field of poultry nutrition. However, more and more research in this field shows that it is advantageous to employ radioactive isotopes in studying the problems involved in the growth, development, production, and utilization of the various elements that enter into egg production. Some of these problems could not be solved without these important byproducts of the atomic age. From the standpoint of mineral metabolism alone, subjects which need detailed study include the role of bone salts and their mobilization, eggshell formation and characteristics, egg composition and changes during hatching, use of supplements, mineral requirements, absorption and excretion of minerals, the blood constituents and their changes, the effect of hormones, and the role of such important trace minerals as manganese.

The basic principle in the use of radioactive materials in the study of nutrition is the fact that the charged atom behaves in

the animal body exactly as does the normal atom, except that it has the property of emitting radiation and thereby telling the scientist what goes on in the life processes of the animal. This radiation can be used to determine exactly where the administered element has gone in the body, how much of it reached a given tissue, and, furthermore, how long it stays there. Such knowledge offers more information than ordinary chemical analysis because it is more sensitive, and because it permits a differentiation between the element that was already present in the tissue and that which was derived from a given dosage. Description of a typical experiment follows.

An 18-month-old White Leghorn laying hen weighing about 3¾ pounds and on a standard ration was fasted overnight. The next morning approximately 1 milligram of radioactive calcium was administered as a calcium chloride solution directly into the lower gullet of the hen by means of a pipette. For 20 days after this dosage, each egg was collected for analyses, and on the twenty-first day the bird was killed to obtain an analysis of blood and bone samples. It is impractical to get quantitative results by external measurements of the animals themselves; hence it is usually necessary to study actual samples of the material. The yolk, white, and shell of each egg were analyzed for both radioactive calcium and total calcium, involving the use of a Geiger counter.

The shell of the first egg laid 24 hours after dosage contained about 3/10 milligram of radioactive calcium which would be interpreted to mean that 30 percent of the calcium that had been fed to the bird had appeared in that first egg. The yolk of the first egg contained a very small amount, about 0.002 percent of the dosage; the white, about 0.1 percent of the calcium. In the second egg, the amount in the shell had fallen to about 3 percent of the calcium dose, the amount in the yolk had increased to about 0.13 percent, and the amount in the white had then decreased to about 0.03 percent of the dosage. This trend was, in general, continued through the fourteenth egg, the shell, yolk, and white from which contained 0.5 percent, 0.01 percent, and 0.002 percent of the dose, respectively. The radioactive calcium of the blood was rather low but a considerable amount of this material was stored in the skeleton.

From this type of study, characteristic of research undertaken by the Florida and Tennessee stations, it has been possible to estimate that from 60 to 75 percent of the calcium in the egg reaches there directly from the calcium of the ration. The shell is laid down on the egg about 20 hours after ovulation. Calcium fed in a given day appears in a number of eggs, and, conversely, the calcium in any given egg comes from the calcium fed on many different days. Some of the calcium in the ration is deposited in the various tissues of the bird, but mainly in the bone. Small amounts of this stored calcium eventually find their way into the egg, and this represents the 25 to 40 percent of the egg calcium which is not derived from the ration. On the basis of past experience, one may assume that a better understanding of these life

processes will in a practical way lead to better management, and to improvement of animal health and production.

Growth inhibitor of alfalfa removed

A big step forward in the economy of producing healthy chicks appears possible in the light of important discoveries by the California, Oregon, Texas, and Colorado stations. Something exists in alfalfa meal which depresses the growth of chicks during their first 8 weeks if more than 5 percent of alfalfa meal is incorporated into the growth ration. Thus, even though a good quality alfalfa meal is regarded as a relatively cheap feedstuff as well as a good source of protein, vitamins, and minerals, nevertheless it cannot be fed except in small amounts because of the growth-inhibiting effect. In Colorado's study of 80 different samples of alfalfa leaf meal used in chick rations, different samples of alfalfa were found to contain varying amounts of the growth inhibitor, and dehydrated alfalfa leaf meal from the third cutting appeared to contain more of the factor than that of earlier cuttings. Research by Texas substantiates the findings of Colorado regarding marked variations in inhibitor-content and shows that inhibitor apparently is not related to molybdenum, as occurring in some cases of cattle on luxuriant pasture in Florida, since the toxin was not neutralized by the feeding of copper.

Evidence obtained at the California station in feeding tests indicates that the growth-depression may be due to saponins, and can be counteracted largely by the inclusion of cholesterol, a type of crystalline alcohol, in alfalfa-containing feeds. Also the toxin can be removed by exhaustive extraction of the alfalfa meal with hot water. The residue so produced has little growth-depressing action, whereas the water extract produces marked inhibition of growth. Similar work at Oregon shows that when the inhibitor is removed, alfalfa meal may be safely added to chick diets in quantities as high as 20 percent without any retardation of chick growth.

Eggs from corn, minerals, and Ladino clover

Several years ago it was demonstrated that chicks would make successful growth when fed on corn, minerals, and Ladino clover. In the past year the Ohio station carried on an April-to-November feeding trial which showed that this combination also successfully stepped up egg production. In a Rhode Island Red flock which had a 6-month-egg-production record of 65 percent at the time of its division into two lots, the hens placed on 1 acre of Ladino range and fed only corn and minerals gave greater production than the other group which was kept indoors on the original ration. Survival was decidedly in favor of the former group. Average monthly weights per bird were practically the same under both systems of management, despite the greater activity of the hens on the range.

The study showed that there was considerable difference between the feed costs of the two systems of management. The corn and minerals ration was made up of 95 percent of coarsely

ground corn, 3 percent of steamed bonemeal, 1 percent of common salt, and 1 percent of chick-size oystershell or high-calcium limestone. With only corn and minerals, outdoor hens had to complete their ration with Ladino pasturage; consequently their eggs required only 4.6 pounds of corn and minerals at a cost of 13 cents a dozen eggs versus 7 pounds of the complete feed indoors at a cost of 25 cents a dozen eggs. Thus 1 acre of Ladino, capable of providing feed for 100 or more laying hens, reduced the feed cost approximately $100.

Egg Investigations

Cleansing soiled eggs

The problem of dirty eggs may readily be solved by proper management of flocks by the farmer. Unfortunately, however, human nature is difficult to change even though dollars and cents are involved. Washing the dirt from eggs is easier than preventing the soiling, so the former practice is followed extensively.

The California station offers evidence to show the harmful results of such a course. During the past year two separate egg-washing field studies were carried out, one at Sacramento for 1 month at one farm, and the other at Petaluma covering 28 ranches, where approximately 79,000 eggs were processed, stored, broken, and examined. All eggs were segregated according to cleanliness or treatment, then oil processed, and stored. Six months later they were removed and broken for examination.

Perhaps the most striking observation made was that the unwashed clean eggs stored as controls were in uniformly excellent condition at the end of the storage period. In over 14,000 eggs examined only 0.2 percent was spoiled, less than 1 egg per case of 360. Unwashed, slightly dirty eggs had very little more spoilage, 0.4 percent, no greater than that of the clean eggs from most ranches. Practically all of the trouble was found to begin in the eggs that had been washed. An average spoilage of 3.6 percent was observed in all eggs washed during both trials by a variety of methods and under different sets of conditions.

At Sacramento, the effect of water temperature from 70° to 140° F. was studied, using a roller-type washer with towel-covered rollers and sprayed water. Although the high water temperatures produced less spoilage than the low water temperatures, the results were not conclusive.

Holding washed and unwashed storage eggs on the floor of the candling room 10 days before examination, a condition less severe than eggs must undergo in some retail markets, caused 10.6 percent loss in ranch-washed eggs and 7.4 percent loss in unwashed, very dirty eggs, but only 0.6 percent spoilage in unwashed and 1.0 percent in dry-cleaned eggs.

The California station concludes that washing eggs before storage is a risky business. The only safe eggs to store are eggs produced clean and left unwashed. Unwashed, slightly dirty eggs are apparently almost as safe, but the keeping quality of any

washed egg is utterly unpredictable at present. Practically all of the eggs that spoil in storage are eggs that have been washed.

VETERINARY MEDICINE

Research in veterinary medicine is so intimately involved with all fields of animal investigations that it frequently becomes difficult to draw lines of demarcation. In recognition of this, experiment station veterinarians often find themselves teamed with agricultural engineers, nutritionists, geneticists, soils specialists, and others in attempts to determine the whys and wherefores of abnormal conditions, diseases, and parasitic invasions of livestock. In addition, as research in animal and human medicine advances, there is a keener awareness of diseases transmissible from animals to man. The State experiment stations, cooperating with Government and private agencies, are conducting intensive research in the field of veterinary medicine on a national as well as regional and local basis. Many worth-while contributions have been made during the 1950 fiscal year. A few examples are summarized in the following paragraphs.

Death Losses in Young Pigs

The little pigs that don't go to market are an economic loss the Nation can ill afford. Experiment stations are engaged in extensive research that should eventually help save a considerable number of the pigs born that now fail to reach weaning age.

According to the Indiana station, the baby pig represents an actual investment of 140 pounds of feed at birth; 260 pounds of feed at 2 weeks of age; and 1,000 pounds of feed at weaning time. It is not consistent to continue to lose 40 percent of the pigs between farrowing time and market age—33 percent before they are weaned. The problem is not simple. It is of such a serious nature that a number of experiment stations have pooled the efforts of their specialists in this field along with those of specialists in the U. S. Department of Agriculture. A number of specific diseases appear to be involved in some of the losses. However, their causes are obscure and it is imperative that they be studied and their characteristics and control determined. Control measures cannot be formulated until the causes are known. Even though the regional study has only recently gotten under way, progress is being made.

In order to determine whether uremia (an excess of urea and other nitrogenous waste in the blood) is responsible for many deaths in newborn pigs, the Illinois station has developed a method of artificially producing the condition, which provides data on the effects of true anemia and makes possible readily available cases for a thorough study of blood constituents.

A filter-passing agent has been isolated by the Indiana station from pigs infected with transmissible gastroenteritis. This agent readily produces disease by artificial inoculation into pigs.

At the Kansas station, studies have been in progress on an anaplasmosis-like disease of swine which is characterized by

general anemia. This disease is becoming increasingly widespread. It usually involves about 10 percent of a herd, and all affected animals die. The station has apparently determined the cause of the disease and is able to transmit it artificially to swine.

Preliminary conclusions by the Michigan station tend to place great stress on the importance of adequate nutrition for the pig from birth to maturity to insure success with its subsequent offspring. The feeding of nutritionally inadequate rations to gilts (young female swine) from weaning until maturity usually resulted in either their failure to conceive, or, if conception was successful, the pigs were abnormal. Mature gilts, on the other hand, that had been adequately nourished until maturity, produced normal pigs even though inadequately nourished prior to breeding and throughout pregnancy. It thus appears that we cannot study the dead or abnormal pig alone but must examine the parents for leads in certain types of pig losses. The Michigan station, in addition, has found a method of curing nutritional enteritis (noninfectious disease characterized by severe inflammation of the intestine) which has decidedly reduced death losses in weanling pigs. It has been estimated that about 5 million pigs suffer from this disease annually.

It has been observed by the Minnesota and Nebraska stations that some sows produce milk poisonous to their pigs. Death occurs within 2 to 3 days after birth unless the pigs are transferred to a synthetic ration made largely from cows' milk, or are placed on foster sows. Studies are under way to determine the character and cause of this toxic principle.

Research at the Ohio station suggests that enteritis in pigs may be due to a number of causes whose eventual classification and differentiation are needed before complete and effective treatment can be carried out with all pigs suffering from this common symptom. This is substantiated by the fact that in certain herds pigs suffering from enteritis were relieved and showed remarkable gains in body weight following vitamin therapy alone. On the other hand, pigs exhibiting similar clinical symptoms failed to respond to vitamin therapy until an antibiotic (streptomycin) was first administered.

The Wisconsin station is interested in virus pneumonia and in the effects of heavy parasite infestation on the health of pigs. The station is also studying nervous disorders in swine that may bear a relationship to similar disorders in humans. The research shows that it is readily possible to isolate strains of swine influenza virus taken from nose swabs of pneumonic pigs in their very early stages of the disease, even before appreciable symptoms have developed.

Pasture Improvement and Parasites

With the marked development in pasture improvement, there has also been an increase in livestock populations on the pastures. This concentration of stock, in turn, has brought about an increase

of parasitism. Probable heavy losses in young animals are to be expected until ways of reducing parasitism are determined. One method, the winter resting of pastures, appears promising and is being studied further by the Georgia station and the U.S. Department of Agriculture in connection with beef cattle production.

Liver fluke infection in cattle

The Puerto Rico station, as a result of its Island-wide survey, found that in one year more than 6.24 percent of cattle livers were condemned because of liver-fluke infestation. Total weight of diseased livers was estimated at 45,871 pounds. Observations at the Hawaii station indicate that liver fluke cysts do not remain viable on pastures from one year to another, even under the best natural environmental conditions. Therefore, pastures vacated of infected animals in which there is no source of new infection and in which the snail population (intermediate hosts) is controlled, should be free of possible source of infection after 1 year. Ability to identify fluke ova in living cattle is difficult, but it is essential in research on and eventual control of the infection. In recognition of this, the Florida station has developed a simple test that is efficient.

Poultry parasites

The Kentucky station reports that all of the 14 species of roundworms and 10 species of tapeworms found in chickens in the United States occur in the South, and that at least 4 percent of these have been reported from no other region.

Blood Bank Saves Long Island Ducklings

An outbreak of what proved to be a highly fatal virus disease in Long Island ducklings occurred during the 1949 brooding season. Conservative estimates of the duck growers in the Eastport and Riverhead area indicate that the mortality from this disease during last year's rearing season was in the neighborhood of 15 percent of total production, which in this case amounted to 900,000 ducklings or a loss of $270,000 if one were to consider only the cost of the day-old ducklings at 30 cents each. Efforts of the New York (Cornell) station failed to identify Newcastle disease in this outbreak. A new virus was recovered and a practical method of control was devised. It consists of injecting into diseased birds immune serum from ducks that have recovered from the disease. Despite the fact that the disease was still present this year as shown by its recurrence in broods in which serum therapy was omitted the previous year, losses have been kept to a minimum. An immune serum bank, sufficient to inoculate about 3 million ducklings, is available to the duck growers in the Long Island area. When the first symptoms of the disease are apparent, all of the ducklings in the brood are immediately injected with the immune serum. Losses cease at once and the brood goes through the rearing period without further difficulty.

It should be noted that this is the first instance in which immune serum therapy has been successfully used on a practical basis on poultry in the Western Hemisphere.

HOME ECONOMICS RESEARCH

Research in home economics has been carried out with the objective of serving the home and the families who live in these homes. The scope of the investigations, whether fundamental or applied, has been dictated by the practical problems of everyday living, from the physical aspects of the home to the nutritional well-being of the family. The few studies discussed below reflect the range of research interest and suggest the applicability of the findings.

Housing

The demand for improved farm housing, either through remodeling of existing structures or the construction of new ones, has pointed to the need for concrete help to the farmer or his builder through information on new materials, plans, and methods of financing. Researches at the experiment stations have shown the need for this information on the one hand, and have been directed toward providing it, on the other hand. Housing research on a regional cooperative basis, carried out in all four regions, is supplemented by independent station researches on particular problems.

Farm housing in the Northeast

The 12 State experiment stations in the Northeast, with the cooperation of the Department, have completed a survey on farm housing, the first step in the regional housing research program. The ultimate objectives of this program are to determine the space requirements for household activities and the development of functional housing plans providing for economical construction and maintenance.

The survey was designed to obtain needed factual data on the nature and scope of household work and family living activities; the family preferences for general housing features and the location of activities; the kinds and quantities of household possessions; and the characteristics of existing houses. This latter point is important since any general housing program aimed at better houses for many farm families must be concerned with the remodeling of existing structures rather than the building of new structures. The comprehensive regional report of this investigation presents the basic survey findings, analyzed to show the effect on housing requirements of such factors as the economic level of the family, stages of the family cycle, size of household, and the location of farms with relation to climate and topography.

Only a few of the more general findings may be cited here to show the value of this housing survey. One of the most significant characteristics found for the farmhouses in the Northeast States

is their age. The median age, where known for the houses surveyed, was 79 years, only 22 percent being under 50 years old and 44 percent over 100 years old. This age characteristic suggests that most of the houses were built to meet needs quite different from those existing today.

Most of the houses are large, the median-size farmhouse in the region having 7.1 rooms. This was an adequate number of rooms for most of the families, since the median-size household of the region was 3.6 persons. About 28 percent of the families, however, reported a need for more rooms than they had in their present homes. Although only 3 percent of the families had a house of only one story, 35 percent preferred a one-story house.

When the families who expressed need for additional rooms were asked what room they would want, over one-third specified another bedroom, or guest room. About 16 percent of the families indicated that a bathroom or a lavatory was preferred, and a few families specified a dining room, utility room, living room, den, or office, as the first additional room desired. In general, the families who wanted a one-and-a-half or a two-story house preferred one bedroom and a bathroom on the first floor. About one-half of all the farm families covered by the report had a pantry and about the same percentage wanted one, either for storage or as a working area, or as a combination of the two. Almost two-thirds of all the farm families covered by the report wanted an office, or at least a desk, in the house for use in their business operations.

Although 94 percent of the houses had a basement or a cellar, an even higher percentage of the families (97 percent) indicated a preference for a basement in the farm home to use primarily for storage of canned goods, produce, and fuel. Many of the families would also use the basement for laundry purposes. Ninety percent of the houses had at least one porch. Ninety-three percent of the families preferred porches, and of this number, more than half wanted both a front and back porch. Almost all of the farm families preferred a central furnace for heating, although only 46 percent of the houses had a furnace. Hard coal and oil were the fuels most generally preferred for furnace use. The kind of heating equipment and the kind of fuel used were governed to some extent by geographical location.

Some of the important activities carried on in the house were meal service, food preparation and preservation, laundering, sewing, and entertaining. A high percentage of the families preferred to carry on some of the household activities in locations different from those now used. Many families now using the kitchen for such activities as ironing, canning and other types of food preservation, and cutting of meat, would prefer other locations. This would indicate that the rooms had not been planned or remodeled to meet the requirements of the family now occupying the building. Some type of laundry or washroom, or a back room that could be used for general work purposes was preferred by a higher percentage of families than now have this type of

room. Two-thirds of the families indicated that space should be provided in any new house for overnight guests.

Storage space was needed in the farmhouse for many items which, in certain respects, may be peculiar to the farm household, such as men's work clothing, a supply of glass jars, crocks, canners, churns, and ice-cream freezers. These were in addition to such items as groceries, produce, dishes, silverware, household appliances, major items of clothing, bedding, magazines, and books, for which storage space must also be provided.

It is obvious from the survey findings that many of the farmhouses in the Northeast do not adequately satisfy today's living or working needs of the families who occupy them. It is highly important, therefore, to develop space standards for the farmhouse and for its equipment and storage space based on the data presented in this report. Such standards will be useful to families in planning new houses and replanning the farm home they now have.

Regional surveys of farm household activities, facilities, and preferences

Regional surveys similar in scope to the one discussed above for the northeastern region have been completed in the north central, southern, and western regions. The data obtained have been summarized and analyzed, and the published reports will soon be available from the several regions.

Analysis of the household storage problem

Household storage has concerned workers at the Oregon station for a long time, and a series of investigations, starting some 15 years ago, recently culminated in a critical analysis of the storage problem. This analysis will be used as a guide for workers continuing with storage research under the western regional housing research program.

The analysis suggests that home storage facilities are good if they furnish convenience, safety, and comfort in use. These facilities must also contribute to household organization and management and to the training of children, and must be a source of satisfaction and pride to the family.

Storage planning is often neglected, or carelessly done, for several reasons. One is the underestimation of its importance by home owners, few of whom know how to plan storage for their own homes. In addition, storage is the most tedious and time-consuming part of house planning, and architects, therefore, generally cannot afford to do a thorough job. Moreover, labor costs for building storage are high.

The Oregon research has shown that in planning storage for specific items, several objectives should be kept in mind. The facilities should insure economy in storage space and construction costs. They should provide means of retarding deterioration of articles stored and of protecting objects from injury from such causes as abrasion, fire, and infestation. Storage provisions

should insure quick and easy use of the stored materials and should allow for keeping these materials in good order with a minimum of time and effort. The storage arrangements should also make it possible to add possessions as family requirements change, or to defer the use of possessions. It should be possible to convert storage spaces to new uses at a minimum of expense. As an over-all requirement, storage should provide for all articles owned by the family, should suit the family's managerial ability and interests, and should be adapted to the family's abiilty to pay for storage facilities.

Home Management

Good management in the home, as in industry, should make it possible for the worker to conserve energy in performing the job. Experimental work on this problem has developed a technique for measuring energy expenditures in household work and for applying the method in making fundamental observations.

Energy costs of household tasks

The energy expended by the homemaker in doing such household tasks as preparing food, washing dishes, storing utensils and supplies, and cleaning and laundering, could be lessened by proper attention to equipment design. This conclusion was reached by workers at the New York (Cornell) station who have been studying the relative energy expended by the body in reaching, bending, stooping, and twisting. These motions were selected for study since they are component parts of the various activities of the homemaker. The energy they require was determined by a special technique in which the amount of oxygen consumed was measured by a closed-circuit metabolism tester "worn" by the women engaging in the experimental activities. The differences in the energy cost of these activities was surprisingly large. Reaching to a height of 56 inches above the floor required twice as much oxygen as reaching to a height of 46 inches; reaching to a height of 72 inches required four times as much as reaching to the 46-inch height. Bending down to 3 inches above the floor required 19 times as much as reaching to the height of 46 inches. These results indicate that the homemaker in reaching above or below work surfaces expends considerable energy which increases by relatively large steps with increasing span of reach.

To gather more concrete evidence for guiding homemakers in their use of equipment, it is planned to make the test observations on women at work in their homes. These findings and the fundamental results already obtained will also be of use to manufacturers in the development of more functional new designs for household equipment.

Food Preservation

Research in the field of food preservation has been directed toward finding the solution of problems involved in freezing,

canning, and storing of foods; the utilization of fruits and vegetables through the development and processing of new products; and the maintenance of quality in these products. Following are a few examples of especial note.

Apple-flavored ice cream

An apple juice concentrate, prepared by a method employing ascorbic acid as an antioxidant, has been developed by the New York State station for use in apple-flavored ices, sherbets, and ice cream. Because of its low acid content, concentrate from McIntosh apples produced better ice cream than that from Baldwin apples, which gave better ices and sherbets. A finished ice, containing 100 percent of apple juice, which can be made with such a concentrate, was considered preferable to ices of a lower concentration. These and other products using apple concentrates, now being investigated by the station, point the way for outlets of surplus McIntosh and other varieties of apples.

Fruit juices improved

Investigations at the Oregon station have also demonstrated the possibilities of preparing new products from surplus fruit crops in the State. The station has obtained a prune juice from fresh frozen prunes which resembles the fresh product in color and flavor. Studies on the canned or bottled juice, not yet completed, will determine its storage life under different experimental conditions.

The low yield of juice from fresh frozen cranberries, usually 40-60 percent in existing commercial pressing methods, has been raised to 82 percent by a method devised by the Oregon station. The products prepared by this method ranked higher in taste than cranberry juices now on the market.

Food dehydration not practicable for home use

A Minnesota study, which aimed to develop equipment and methods suitable for home dehydration of fruits and vegetables, indicates that this method has too few advantages to warrant its use by the homemaker. Application of dehydration methods in the home was found impractical because of the difficulty in attaining the required control of temperature and humidity, and of the inability of the home processor to determine the correct moisture content of the product for satisfactory storage. In addition to these disadvantages, the time element involved in completing the dehydration process and the poor quality of the resultant product, make either canning or freezing a more practical method of preservation.

An exception to the above findings is suggested by a Wyoming study which found that dehydration is a suitable method of preserving green beans in the dry, high altitude of the State. The impossibility of freezing preservation in isolated areas, where rural electrification is not extended, and spoilage losses of low-acid vegetables canned without pressure cookers point up advantages to the dehydation process.

Food Preparation

Cake is a popular dessert with most families, but busy homemakers agree that baking is too time-consuming. Requests for information on the comparative quality, cost, and actual time saved by using frozen cake batters, frozen pre-baked cakes, and prepared cake mixes have prompted research in several stations on the solution of these problems.

Short-cuts to cake baking

Cake mixes which can be prepared at home in sufficient quantity for six cakes have been developed by the New York (Cornell) station. When stored in dark, cool, dry places, these mixes can be kept for at least 6 weeks and made as needed by adding the egg and liquid to a jar of mix, beating them in, and baking. A study of cakes made from these mixes has shown that satisfactory cakes can be made with cake, pastry, or all-purpose flour. Hydrogenated shortening, as the fat ingredient, produced cakes of better volume and texture than did combinations of hydrogenated shortening and butter and mixtures of hydrogenated shortening and lard. These cakes, however, did not have the butter flavor preferred by some of the persons judging the product. Different kinds of cakes from the same mix were made by incorporating spices, orange rind, lemon or orange extract, or chocolate.

Colorado homemakers who purchased commercially prepared cake mixes have found that these products, packaged in other States, were unsuitable for baking at the high altitudes in their own areas. Reliable and standardized pre-mixes for biscuits, waffles, pancakes, muffins, rolls, cookies, and cakes have been developed by the Colorado station for use at altitudes of 5,000, 7,500, and 10,000 feet. The mix has been found to be convenient, costs less than ready prepared products, and has good storage qualities.

At the Illinois station, an investigation was undertaken to study the effect of freezing on the quality of plain shortened cakes, and to determine whether cakes baked before freezing differed from those prepared from batter which had been frozen. Freshly baked cakes, cakes baked from frozen or thawed frozen batter, and reheated frozen cakes were compared on the bases of volume, compressibility, and palatability after 1, 4, 8, 12, and 16 weeks of freezer storage. The various cakes, judged by a panel 2 hours after baking or reheating, were rated from good to very good. The best cakes, from the standpoint of palatability and volume, were those which had been baked from frozen batter stored in cartons. It was found that the extra step of thawing the batter before baking was not necessary, since it did not improve the palatability of the cake.

Other studies which deal with home-baked products include one conducted at the Oregon station on the influence of baking pan material on the quality of cakes with fat as an ingredient. Results obtained from the study point out that the material from

which cake pans are made does influence baking results, but that none is superior in all respects. Dark or dull materials, such as japanned iron, anodized aluminum, and sheet iron, proved to be faster baking metals and produced cakes of greater volume and over-all crumb quality than cakes baked in bright aluminum, tinned iron, stainless steel, or copper pans. The brighter pans, however, produced cakes which had a higher degree and evenness of brownness. The steel pan, which was more efficient in baking time than a similar pan made from glass, yielded cakes superior in crumb quality and brownness of crust, but inferior in shape. The volume of cakes baked in the glass and steel pans did not differ significantly.

Nutritive Value of Foods and Human Nutrition

Provision for the nutritional well-being of the population involves not only a knowledge of the nutrient composition of foods but also information on the availability to the body of these nutrients as they exist in different food sources. Other considerations include the dietary habits of people, the acceptability of new or additional foods that may improve their diets, and the problem of making use of available food resources. A brief account of a few of the researches by station nutrition workers will indicate that attention has been given to the nutritional considerations here listed.

Processed rice in Hawaii

Family diet studies made by the Hawaii station have shown that the per capita consumption of rice for all people in the Islands is about 120 pounds per year. More than half of the people of Hawaii are of racial stocks that use rice as a staple and basic food; among this group, the consumption of rice ranges from 200 to more than 300 pounds per year. Much of this is white rice. With a view to improving the basic diet of the rice-eating people, the Hawaii station has made an intensive comparison of the nutritive value of white rice with that of brown and processed rices, and has obtained information on the acceptability of the latter two in comparison with the white rice to which the people are accustomed. Analyses of brown, white, and processed rice from the same source, of commercial origin, showed that the milling of brown rice resulted in loss of vitamins and minerals. If the rice is processed (i.e., baked or steamed and then dried) before milling, the losses are reduced. On an average, the processed rice was 101 percent higher in thiamine content, 210 percent higher in niacin, 197 percent higher in calcium, 56 percent higher in phosphorus, and 78 percent higher in iron than white rice. Processed rice contained less than brown rice of all these nutrients except calcium and niacin.

These figures were obtained on fresh shipments of the raw rices. Since rice is not eaten in the raw form, the study was extended to determine how various factors in operation would influence the nutritive value. Storage of the rices, both under

actual commercial warehouse conditions and in small lots under laboratory conditions, resulted in loss of thiamine and niacin. Washing the rice before cooking, a common practice, resulted in mineral as well as vitamin losses. These losses, which became greater with several washings, were not the same for the various nutrients, or the different kinds of rice; brown rice lost a smaller percentage of its nutrients through washing than white or processed rice. Thiamine loss only was investigated in the cooked rices. It was found that rice which was not washed, or was washed only once, and cooked in amounts of water which could be absorbed, showed maximum retention of thiamine. Cooking in a large amount of water which was discarded or cooking in the pressure saucepan caused more loss of thiamine than other methods.

The practical implications of these successive losses have been summed up in the case of thiamine, which is a nutrient critically low in the diet of the rice-eating people. The Hawaii investigators have estimated that a pound of brown rice stored 4 months, then washed seven times and cooked without discarding the cooking water, as is common practice in Hawaii, would supply more than half of the required daily allowance of thiamine recommended by the National Research Council. Processed rice would supply one-fifth and white rice about one-twentieth of this daily allowance of thiamine. On the basis of these data, it is easy to understand the occurrence of beriberi among people who eat large amounts of white rice and whose practice it is to wash it thoroughly.

In addition to the possible losses of thiamine from rice in storing, washing, and cooking, the physiological availability of this vitamin, an important consideration, was investigated. Thiamine excretions of six human subjects reflected the availability of the thiamine in processed rice and demonstrated the improvement in thiamine nutrition caused by substituting processed rice for white rice in the diet.

The findings from this Hawaiian study suggested increased use of brown rice, or processed rice, as a solution to the problem of thiamine deficiency among people whose daily diet is based on rice. The feasibility of this practice, it was recognized, will be dependent on whether the quality of these rices will hold up under storage and whether the consumer will accept the brown and polished rices as readily as he has accepted white rice. Additional work was conducted, therefore, to throw light on these problems.

It was found that under conditions of commercial warehouse storage, the infestation in the brown rice was considerably greater than in the other kinds. The processed rice, possibly due to its lower moisture content and the hardness of the grains, appeared to be slightly less susceptible to infestation than the white rice. This storage advantage, is a point in favor of the processed rice. A study of acceptance of brown, white, and processed rice by children in seven public school cafeterias in Hawaii, and by 200 Honolulu families, showed that white rice was preferred.

There was an indication, however, that any opposition to the processed rice might be overcome, especially in the schools where education would influence acceptability.

The various phases of investigation conducted in the course of this Hawaii station research suggest that wider use of processed rice in Hawaii is possible and that such practice will provide a practical means of improving the dietaries of the rice-eating peoples.

Nutritional quality of the Puerto Rican dietary

Previous studies of food consumption in Puerto Rico pointed to the nutritional inadequacies of the Puerto Rican diet, particularly with respect to the protective foods. More precise evaluation of the food consumption data in terms of specific nutrients was not possible, however, because of lack of information on the composition and nutritive value of the tropical fruits and vegetables and other foodstuffs either produced or consumed in Puerto Rico. Work was undertaken, therefore, to determine the vitamin content of a large number of the foods commonly used in the dietary.

Data on thiamine values have shown that the bulk of the thiamine in the average diet is contributed by the dried beans and root crops which together account for more than 25 percent of the weight of the whole diet in Puerto Rico. Results reported on the riboflavin analyses indicate that the restricted diets found among the poorer population groups are low in riboflavin since all the major components, except beans, are poor sources of this vitamin. Skin lesions suggesting riboflavin deficiencies are not uncommon in this segment of the population. Recently, niacin determinations have been completed on more than 80 foods, ascorbic acid analyses have been undertaken, and green and ripe plantains, widely used in the diet, have been assayed for vitamin A.

Results to date suggest that the green plantains are superior to the ripe plantains as a source of vitamin A. A significant finding in the course of the ascorbic acid investigation was that the West Indian cherry, *Malphigia punicifolia,* is one of the richest, if not the richest, vegetable source of ascorbic acid known. This fruit, containing as much as 3 mg. of ascorbic acid per 100 gm. of edible flesh, bids fair to become an important source of the vitamin in the Puerto Rican diet. The small tree thrives and yields abundantly under Puerto Rican conditions.

Another investigation at the Puerto Rico station was concerned with determining the folic acid activity of tropical foods. In this study rats were used as assay animals. A fundamental finding of this research concerned the assay animals. It was found that a high percentage of those that had been depleted of folic acid developed lesions of the spleen which presented a characteristic pathological and bacteriological picture.

The data obtained on the foods show that the typical Puerto Rican diet of the type observed in the earlier food consumption study is a very poor source of folic acid. It is probable that

the low amount of folic acid activity of this diet may account for the high incidence of macrocytic anemia observed in Puerto Rico. The results of the food assays suggest that several foods readily available could be used to increase the folic acid activity of the diets. One of these is a dried food yeast, *Torula utilis,* now being produced commercially on the Island. This yeast is very rich in the vitamin and could be used to fortify the poor diets. Legumes were also found to be a good source of folic acid activity, although not so rich as the food yeast. Among the fresh fruits assayed, the avocado proved to be the only one with appreciable folic acid activity. In Puerto Rico almost the whole avocado crop is obtained from wild trees. It is being largely consumed locally and no doubt has a corrective effect on the diet.

RESEARCH IN THE SOCIAL SCIENCES

Managerial ability and higher living standards on the farm usually reflect the extent to which the operator and his family utilize the findings of agricultural research. It is on the farm that the need for fitting together the results of research in the physical sciences and in the social sciences becomes most immediately apparent. Therefore, research in farm management, agricultural marketing, farm finance, land economics, and rural sociology is closely geared to research in such fields as plant improvement and animal husbandry. The results of such research at the experiment stations become immediately available to farm people through the programs of the extension services which are closely linked with the experiment stations as cooperative agencies of the land-grant institutions. The Research and Marketing Act of 1946 has made an increased amount of agricultural economics and marketing research possible at the experiment stations. Following are summaries of a few of the significant results reported along these lines in the past year.

Farm Management

Management of New York poultry farms

Results from a New York (Cornell) station poultry farm study indicate that most poultrymen do not start early enough to take full advantage of fall prices and are unable to obtain the advantage of the high summer prices. The returns from the farms studied showed a definite tendency to increase from a low with fall housing of pullets to a high with spring housing. September was the low month, with returns of $9,901, and April the high month, with $10,618. The profit was highest, $3,809, with April housing. Regardless of whether pullets were housed earlier or later, the profit declined from the April high to a low of about $3,120 with August and September housing. This difference in profit of about $700, was primarily due to differences in returns for eggs rather than differences in their production costs. These results indicate that profitable adjustments might be made by many poultrymen in New York State. Since April housing of

pullets proved to be the most profitable, a suggested system of operation would be to start the chicks in November and put the pullets into the laying houses in the latter part of April.

Migrant farm labor in Indiana

The Indiana station reports that approximately 19,000 seasonal farm workers are needed in the production of truck corps, 13,000 of which must come from outside the State. The peak employment period for migrants usually extends from about September 15 until October 10. Texas furnished 68 percent of the workers surveyed; Arkansas, 19 percent; Missouri, 7 percent; Tennessee, 3 percent; and Kentucky, 2 percent. Other States furnished only 1 percent.

Texans of Mexican extraction came as family groups under the direction of a crew leader. Southern white workers came in smaller groups with a large number of single workers. Factory camps housed 51 percent of the workers, and 46 percent were housed on farms. Over 42 percent of the workers were in Indiana for 10 weeks or longer, and only 13 percent were present for 6 weeks or less. Workers desired information in regard to crop conditions, routes, housing facilities, and rest camps. Crew leaders received the wages and made the financial arrangements with the employers for 75 percent of the workers. Recruiting interstate workers can be simplified and expedited to a high degree if canners and processors will make the contacts and arrangements for their growers.

Mineral rights as a source of farm income

A recent survey by the Oklahoma station revealed that, in four typical oil fields of the State, landowners as a group receive not more than half of the royalty income in producing fields. According to the survey, it would have been more profitable for the group to have retained its mineral rights than to have sold, even making allowance for the uncertainty involved. A study of 30 counties of western Oklahoma showed that income from leases and bonuses alone amounts to about one-fourth of the total land income and that 62 percent of all farmers participate in this income. Total income from leasing averaged $6,000,000 per year in this area, which was probably a better return than other investments made on the surface of the land.

Financial status and security of farmers

In a study of the financial status and security of farmers, the Maryland station found that financial status appeared to be the most important factor influencing farmers' attitude toward the extension to farmers of a social security program similar to that available to other groups at present. Of all farmers studied, 56 percent were in favor of a social security program for farmers themselves and 60 percent for farm laborers. The total assets of farmers opposed to a social security program average $34,851 per farm as compared with $22,001 for farmers in favor of a program. The net worth of those opposed to a social security

program averaged $32,659 per farm as compared with $20,153 for those favoring a program. About 70 percent of the farmers favored a social security program until the net worth increased to the $20,000 to $30,000 group, and as it increased beyond this amount, about 70 percent of the farmers opposed it. There was no significant relationship between age of operator and attitude on social security. A majority, 56 percent, of those farmers over 65 years of age were opposed to a program applied to farmers.

Land Economics

Submarginal land ownership in central Oregon

The Oregon station completed a study of land ownership to determine whether it would be to the best interests of a large majority of the people of Jefferson County to return to private ownerships the submarginal land that had been taken over by the Federal Government under its resettlement program. The question was put to the Oregon station by the County Court and the County Land-Use Committee. This Government ownership was resulting in an annual loss amounting, in 1947–48, to as much as $19,000.

The station collected the necessary data and compiled the information needed to formulate an intelligent answer to the problem. The facts were analyzed impartially and put before the county in a compact report which showed that continued Government ownership with satisfactory local control of grazing on these lands would provide the most advantageous situation under existing conditions. Grazing was found to be the best use of such land at present and Government ownership would give best assurance that the land will continue to be used for grazing and will serve the needs of local ranchers and prevent the unfortunate situation of a few years ago when scanty yields on these lands threw the wheat farmers on relief.

Economics of soil conservation

The Maryland station made comparisons of records taken on 16 farms for 1946 and 1947 with historical farm-management records for the same farms in 1929–31. In the intervening period between these studies the farmers with conservation plans reduced their row crop acreages by 22 percent as compared to a decrease of 3 percent on farms without conservation plans. Conversely, those in the conservation program increased more rapidly their acreages of perennial sod and permanent pasture—27 percent perennial legumes and grass acreage as compared to 13 percent on farms without conservation plans. On most of the farms hybrid seed corn was planted, and yields were increased by 50 percent on farms in the conservation program as compared with 19 percent for farms without conservation plans. The animal unit carrying capacity of cropland and pasture was increased by 30 percent on farms using conservation plans, whereas those not following the program increased only 9 percent.

Agricultural Marketing and Purchasing

Losses from sale of high-moisture Burley tobacco

The Kentucky station reports that in 1948 growers suffered heavy losses from the sale of Burley tobacco in which the moisture content of leaves was too high. Losses ranged up to $20 per 100 pounds, depending on grade and quality. Largest losses in price per pound occurred in the low fifth qualities of Flyings, Lugs, and Tan Leaf grades. Largest percentage losses also occurred in these grades, but varied less between grades when measured in percentage of the price of sound tobacco than when measured in price per pound. Losses in price of 15 to 30 percent were recorded on nearly all grades of Burley tobacco in such condition as to be graded "W."

The greatest total loss to growers from the sale of tobacco in doubtful keeping order ("W") or unsound ("U") came in the Leaf grades, because of their predominance in the market and their susceptibility to high-moisture content. The next greatest loss came in the sale of Lugs, because of their relative importance and the sharp price discounts for "W" and "U" tobacco in this group. Fortunately, proper care of the crop can eliminate excessive moisture in tobacco, even in unfavorable seasons. The tobacco should be marketed with just enough moisture content to avoid breakage.

Marketing cattle and calves through the Spokane stockyards

In a study of the marketing of cattle and calves, for the years 1937, 1942, and 1947, the Washington station found that over 90 percent of the livestock marketed through the Old Union Stockyards comes from within a 200-mile radius of Spokane. Over two-thirds of all livestock sold at this market is of Washington origin. Most marketings occur in the fall months, some fat stock being sold in the spring. Highest prices for livestock are received in the late spring and early summer; lowest prices in late fall and early winter. Prices paid for slaughter cattle vary directly with weight and are affected to some extent by the general condition of other livestock markets.

Prices paid for feeder cattle are more closely associated with numbers marketed than with the weight of the animal, and are less responsive to conditions on other markets than are prices for slaughter cattle. The price spread between feeder animals, and fat animals at some later period after being fattened, is greatest for purchases made during the late fall and early winter—there is less profitable spread for spring-purchased feeders, and little or none during the remainder of the year.

Roadside marketing in Vermont

The Vermont station studied 145 roadside markets, or nearly all that were located along the 450 miles of the main Vermont highways. The results indicated that the average sales per market amounted to $2,823 per year. A great variety of products was

handled. Some markets carried a complete line of local farm produce, whereas others carried relatively few. The bulk of the annual sales, 89 percent, was made between June and October. The most important days from the point of view of sales were found to be week ends and holidays. The hours from 4 to 6 in the afternoon were the best for roadside selling. About $900 worth of labor was involved as an average for each market, and the bulk of the labor, 86 percent, was furnished by the family. Consumers from all walks of life and from different localities bought at roadside markets.

Sales volume depended first upon attracting a large number of customers and second upon satisfying the demand of these customers once they had stopped. The factors that attracted customers were advertising and market location or convenience. Attractive signs which were easy to read and placed so that customers approaching the market had ample time to stop, proved effective. The quantity and attractiveness of the display also had much to do with inducing prospective customers to stop. Consumers associated quality with the quantity and attractiveness of the products. They also associated reliability with neat and orderly markets. Desirable locations for markets were on heavily traveled roads, situated in such a way that they could be readily seen by traffic approaching from both sides. Freshness was the most important element of quality from the consumers' viewpoint. This was important to the market operator because he was in a better position than other merchants to supply fresh produce.

Apple marketing losses through bruising

The 12 North Central experiment stations undertook a regional study of losses accruing to farmers as the result of bruises and other damages to apples in the marketing process. Samples obtained on various retail markets in the region were sent to the Illinois station for appraisal of damages.

The Ohio station, in its part of a North Central regional project on the bruising of apples, found that on the farm a great deal of unnecessary bruising occurred in picking, dumping into field crates, and hauling to the packing shed. Other parts of the study, carried on by the Illinois and Ohio stations, showed that apples shipped in ring-faced bushel baskets to retail markets were more bruised than those shipped jumble packed in other types of containers. Of the apples inspected for this study, only one-third of the Delicious variety and one-fifth of the Stayman Winesap variety were free of bruises upon arrival at the packing shed. At the retail level, apples with no bruises were practically nonexistent and those with severe bruises made up about one-eight of the total. Of the Delicious apples inspected at the retail level, 8.3 percent of those shipped jumble packed in containers other than bushel baskets were severely bruised compared with 12.1 percent of those shipped in ring-faced baskets. Comparable figures for the Stayman Winesap variety indicated

that 10.5 percent of those shipped jumble packed were severely bruised compared with 14.6 percent of those shipped in bushel baskets.

Farmers' purchasing cooperatives

The Tennessee station reports that the number of purchasing cooperatives in the State nearly doubled over a 10-year period. In 1938, the number of associations buying farm supplies cooperatively was 59, with 16,171 members and sales of $889,000 worth of farm supplies. In 1947, there were 107 organizations. They reported 33,555 members, and did a business of $3,159,878. Adjusted for the higher level in farm prices the 1947 business was 76 percent above the 1938 volume. Estimated net savings, as a proportion of sales, increased from 2.4 percent for 59 associations in 1938 to 5.8 percent for 107 associations in 1947. Total estimated savings for these years rose from $23,475 to $183,444. Information obtained from this study indicates that associations are encountering many difficulties, the more important of which are: Membership education, lack of operating capital, securing competent personnel, inadequate building facilities, and purchasing at the wholesale level. Lack of operating capital is being overcome by the associations through increased member investments, with less dependence upon borrowing. At the end of 1947 it is estimated that 33,555 farmers had an investment of $835,000, or about an 80-percent equity, in 107 associations.

Farmers who spend the most money for farm supplies usually do not purchase cooperatively as large a percentage of their supplies as do the smaller farmers. In 1947 nearly 15 percent of all farmers in Tennessee were members of associations that purchased farm supplies cooperatively, but their purchases represented less than 3 percent of that spent by all of the farmers of the State for supplies such as feed, seed, fertilizer, equipment, and petroleum products. Some larger farmers have established other satisfactory trade and business connections whereby they can purchase supplies at wholesale. A number of factors are favorable for further development of cooperative buying of farm supplies in Tennessee. Existing organizations are not completely serving their local areas; only a small proportion of farm supplies in Tennessee are now purchased cooperatively. In both 1938 and 1947 less than 3 percent of such supplies were purchased through farmers' cooperatives; local purchasing cooperatives are expanding their facilities and broadening their range of services, handling more lines of farm supplies, and offering such services as seed cleaning and marketing, poultry and livestock auctions, transportation of farm produce to market, and delivery service to the farm, these facilities tending to expand patronage and to increase volume of business. Persons contacted while gathering data for this study reported an increasing interest on the part of farmers in cooperative buying, this being especially true of veterans taking "on the farm training."

A Southern States' cooperative extended limited services into the area of northeastern Tennessee, adjacent to and contiguous with Kentucky and Virginia, in 1947. In 1948 this organization began organizing retail cooperatives and private service agencies in several counties of east Tennessee. Most of the cooperatives are improving their financial position, by setting aside some savings as general reserves, retiring debts, and increasing investments on the part of the farmers.

Farmers' cooperatives in north Georgia

The Georgia station reports that in general the financial status of 13 farmers' cooperatives in north Georgia improved over the 4-year period, 1944–47, as reflected by their financial statements. Important factors for these organizations to consider are: (1) Length of credit—it is easy in prosperous times for business units to over-extend credit and to slacken on credit policies; (2) patrons' equity should be distributed as patronage dividends only to such an extent that the net worth of the organizations may not become impaired. During prosperous times a good opportunity exists for the cooperatives to build their reserves against future contingencies.

There seems to be an excellent opportunity for the Georgia cooperatives to increase their volume of business through increased marketings. The farmers of the area have a part to play in the building of the cooperatives into stronger institutions, especially by helping to market more produce through the coops. The larger volume would permit the coops to market at a lower unit cost and at the same time to increase their savings. The savings could be used to furnish better facilities which would be owned by the members, the balance to be distributed as patronage dividends from time to time. Inventories should be watched carefully to prevent losses from decline in prices and value of the inventories. The margins retained should be about the same on all activities in order to simplify accounting and to provide a simple and equitable basis for distribution of patronage dividends and ownership of the assets of the organizations.

Marketing feeder cattle in North Dakota

The North Dakota station reports that a study on marketing feeder cattle shows that opportunities for substantial reductions in the cost of marketing feeder cattle and sheep from farms and ranches in that State are limited. Most producers ship only a few head at a time. But through cooperative shipping associations, the cost disadvantages of small shipments are overcome to some extent by efficient routing of truck operators which keeps transportation costs at a minimum. In most cases farmers get a competitive market price and accurate weights for their cattle.

During 1947, about 40 percent of farmers' sales were made to terminal markets, 28 percent to dealers, 19 percent to auctions, 10 percent to concentration yards, and 4 percent directly to farmers.

Sales by the head were made almost entirely to local dealers but accounted for only 20 percent of farm sales to dealers. About 94 percent of the feeder cattle sold from farms in North Dakota during 1947 were made on a "weight" basis. Generally speaking, farmers and ranchers involved in buying or selling feeder cattle and sheep were satisfied with existing marketing practices. There was an apparent lack of concern among the majority of producers on the question of improving marketing efficiency for feeder livestock. Although reductions in costs of marketing feeder cattle and sheep in North Dakota are not likely to be substantial, farmers should work for an extension of "direct-buying," for improved transportation, and for increased competition among the buyers and smaller markets in the field. The individual producer should be alert to the possibility of taking advantage of the price differentials existing in the various markets at any given time.

Factors affecting milk marketing in Indianapolis

The Indiana station was asked to undertake an economic analysis of the Indianapolis milk market to provide a basis for policy changes. This necessitated analysis of fundamental factors affecting supplies and consumption in the market, and of the pricing and marketing policies necessary to achieve a working balance between supplies and consumption, both annually and seasonally. The organization of the market was found, in general to be such as to promote efficient bargaining and marketing of milk. Merger of the five producers' associations offered possible significant reductions in marketing costs and the possibility of more effective service to producer members. The consumption of milk per capita appeared to be affected by the retail price of milk, prices of all goods (cost of living), and current and past disposable incomes. The demand for milk appeared to be highly inelastic with respect to both prices and income.

The study revealed that milk production in central Indiana was affected by milk and feed prices, heifers saved in prior years, and by technological change. Milk deliveries to the city were affected by these variables, but to a much greater extent by the relation of producer prices in Indianapolis to prices in competing markets. The study indicated that a working balance between deliveries and dealers' sales in the market is essential. To achieve this the class II price must be approximately equal to prices paid at manufacturing milk plants near Indianapolis. The class I price should average about 35 to 40 percent above the class II price. Seasonal price variations to producers can best be made through changes in the class I price. This price probably should be close to 35 percent higher in November and December than in May and June. The producer blend price then will be about 45 percent. This latter figure approximates seasonal differences in costs in the two periods.

Marketing hatching eggs in New Hampshire

The New Hampshire station reports that the hatching egg business is the most important phase of the poultry industry in that State. The New Hampshire breed made up about 88 percent of all birds blood tested in 1948–49. Losses in the shipping of hatching eggs create a problem. Claims in connection with rail shipments varied greatly. On a shipment of 6,000 cases by two shippers, one made claims involving under 1 percent of cases shipped while the other made claims involving 13 percent. Careful packing, use of good cases, and inspection of eggs are all important shipping factors. Premiums in hatching eggs in 1947 varied from 10 to 16 cents per dozen and averaged 12 cents. Fifty-three percent of the eggs were from barred crosses and 40 percent from New Hampshires. Nearly three-fourths of the hatching eggs went for broiler production. Hatching egg sales made up almost two-thirds of the total egg sales. Destinations of eggs were New England, 10 percent; Middle Atlantic States, 52 percent; Southern States, 31 percent; and Western States, 7 percent. Egg breakage (trucked) totaled about 4 percent, half of which occurred between terminal and hatchery. Egg breakage in corners of the case was about twice the average breakage in the whole case. Cases used were about 21 percent heavy returnable wooden, 10 percent new commercial wooden, 21 percent seamed hard commercial wooden, 11 percent new fiber, and 37 percent seamed hand fiber.

Rural Sociology

Texas farm population trends

According to the Texas station the farm population of the State declined by 11,000 persons during 1948. The number of persons living on Texas farms and ranches on January 1, 1949, was estimated to be 1,701,000. About one out of four of the people in Texas were farming or ranching on that date. The population living on farms or ranches in Texas in 1920 was 49 percent; in 1930, 41 percent; in 1940, 33 percent; and in 1949, 23 percent of the total. For the nation as a whole, 19 percent of the population was living on farms on January 1, 1949. In one generation's time, Texas has passed from a State of predominantly farm characteristics to one in which the urban and rural-nonfarm segments outnumber the rural-farm population three to one. Although the total national farm population showed more than a 1 percent increase during 1948, the Texas farm population showed a decrease of 0.5 of 1 percent. Another comparison may be made by taking the 1930 farm population figures for Texas and the United States as 100 percent. Using this base, Texas' farm population is 73 percent of its 1930 figure, and the comparable figure for the United States is 92 percent.

Population trends in Mississippi

In a study of population trends in Mississippi, the State experiment station found that although the population in the State continues to increase, the rate of growth is not as rapid as in

early years. This trend alone would indicate that Mississippi is approaching a stationary population. However, the analysis of the age and sex composition and the replacement indices reveals that the State still has a phenomenal capacity to expand.

Migration is the primary factor causing the population to remain almost stationary. The migratory stream is composed primarily of young people in their early productive years. In the white population young women migrate at an earlier age than young men, and a larger number of young women are leaving Mississippi rural areas. In the nonwhite population groups young men predominate in the migratory stream. This extensive outmigration of young productive workers tends to depress the replacement indices for the State. It further tends to create a shortage of labor, especially of agricultural workers. Although this movement out of the State is taking place, another readjustment of population is taking place within the State. This is a concentration of people in urban centers. The shift of population from farms to cities further augments the shortage of young people and of workers in their early productive years in rural areas of Mississippi. The trend toward urbanization has been more pronounced in the period following 1940 than in the preceding decades.

Finally, the differential migration rates between the white and nonwhite population groups have resulted in a change in the importance of the white and nonwhite racial groups in the State. In 1940 there were more white than nonwhite peoples in the State. Since nonwhite people are predominantly farm people, they have contributed a proportionately larger number of the migrants to the migratory stream out of the State. In 1948 the State had an estimated population of 2,112,000, of which approximately 35 percent were living in urban areas and less than 45 percent were nonwhite.

Fertility trends of rural population

In a study of fertility trends of rural population by the Pennsylvania station, it was found that a disproportionate share of future generations evidently is born and reared in socially and economically disadvantaged homes and communities. High fertility is characteristic of the smaller villages, those more remote from urban influences, and villages with prevailingly low standards of living as indicated by poor housing conditions and low home rentals. Low fertility is characteristic of the larger villages, those located near large cities, and villages with prevailingly high standards of living. Prevailing standard of living seems to be the major single factor influencing fertilty. Where average monthly rents exceed $28, village fertility is 22 percent below the average for all villages; where rents are below $11, fertility is 20 percent above average. Standard of living appears also to be highly important in the fertility of the rural farm population.

Accidental deaths of farm people in Ohio

In a study of deaths of farm people caused by accidents the Ohio station found that 9 farm people a week met accidental

death in Ohio during the 4-year period 1946–49. The annual average was 460 per year. During a life span of 60 years a farm person has one chance in thirty of dying as a result of an accident. Twice as many men and boys met with fatal accidents as did women and girls. Accidents that cause death occur to people of all ages. But a very large proportion of them happen to older people. About one-half of those who had fatal accidents were over 60 years of age.

There was about one fatal accident on the farm every 3 days, whereas in the farm home there was one every 2 days and one every 2 days to farm people when they were off the farm. In the State, during the 4-year period studied, there were nearly five accidental deaths to farm people every 4 days. Tractor accidents were the most frequent type of fatal accidents on the farm; falls and fractures in the home; and automobile accidents when farm people were off the farm. Many accidents that caused the death of farm people could have been prevented. If fewer chances were taken and if greater care were exercised, many of the 1,841 Ohio farm people who met with fatal accidents in the last 4 years might be alive today.

Medical care in rural Virginia

The Virginia station, reporting on a study of medical care in rural areas, reached the following conclusions: Although country people benefited in many ways from medical advances, they have benefited less than other major groups, and their medical care needs are inadequately met. The shortage of rural doctors is growing more acute. Country people, through their organizations, are to an increasing degree demanding better medical services. The question of rural medical care cannot be dealt with as an isolated problem. There should be more consideration of the medical care system as a related whole, and more appreciation of the fact that changes springing from medical advances call for changes in the system of furnishing medical care. Much effort and large amounts of money are now being put into improvement of medical care, especially into the development of an integrated hospital health-center system. To supplement this development, there is need for broader-coverage medical care insurance plans and more extended use of such insurance. There is need of a more vigorous program of preventive medicine. There is also great need for more adequate care of the mentally and emotionally ill, including the expansion of mental hygiene clinics, and an accompanying educational program.

STATISTICS—PERSONNEL, PUBLICATIONS, INCOME, AND EXPENDITURES

Personnel and Publications

The research personnel of the experiment stations in 1950 included 3,292 staff members devoting full time to station research and 3,651 who divided time between research and teaching or extension work. The total in both categories, 6,943, represented an

increase of 1,098 over the total of 1949. There were also 456 more full-time workers in 1950.

Publications of the experiment stations in 1950 included 868 bulletins, circulars, and reports; 3,397 articles in scientific journals; and 1,256 miscellaneous publications. By comparison with 1949, the stations published 100 more bulletins, circulars, and reports, 268 more articles in scientific journals, and 487 more miscellaneous publications.

Data by individual States relating to personnel and publications are shown in table 1.

Income and Expenditures

Appropriations under the authorizations of the Hatch, Adams, and Purnell Acts for use by the experiment stations in 1950 totaled $4,542,500, each State, Hawaii, and Puerto Rico receiving $90,000 and Alaska $42,500. A total of $2,863,708 was appropriated under the Bankhead-Jones Act of June 29, 1935, with allotments to the individual States, Hawaii, Alaska, and Puerto Rico as shown in table 2. These allotments are made primarily on the basis of rural population adjusted in accordance with the provisions of the Department of Agriculture Organic Act of 1944. The total amount of Federal-grant funds appropriated to this Office under the Hatch, Adams, and Purnell Acts, and title I of the Bankhead-Jones Act, was $7,406,208.

Under title I, section 9, of the Research and Marketing Act of 1946, $5,000,000 was appropriated. Of this total $150,000, authorized by section 9 (c) of the act, was available to the Office of Experiment Stations for administration. Of the remainder $3,600,000 was allotted to the States, Hawaii, Alaska, and Puerto Rico, under the formulas described in sections 9 (b) (1) and (2); $1,250,000 was available for allotment to the States for cooperative regional research projects authorized by section 9 (b) (3) and for travel by the Committee of Nine established in accordance with this section. The amounts allotted under sections 9 (b) (1), (2), and (3) are shown in table 2. Also shown are the unexpended balances of allotments for fiscal year 1949, which were available for expenditure during fiscal year 1950.

In addition to the Federal-grant funds enumerated above, the Office received funds from title II of the Research and Marketing Act for allotment to the State agricultural experiment stations for marketing research. Allotments totaling $292,150 were made to the stations during the fiscal year 1950 (table 2).

Non-Federal income of the stations appears in table 3.

Expenditures of Federal-grant funds are shown under object classes by individual experiment stations in tables 4, 5, 6, 7, 8, and 9; expenditures of non-Federal funds are indicated in table 10. The 1950 expenditures of non-Federal funds which include State appropriations, research grants, and income from other sources totaled $45,204,956.85, as compared with $40,304,508.38 in 1949. The 1950 non-Federal fund expenditures by all of the

stations approximated $3.69 for each $1 of Federal grants. Summaries of expenditures appear in tables 11 and 12.

Expenditures and allotments of funds from title II of the Research and Marketing Act are shown in table 13.

TABLE 1.—*Organization, personnel, and publications of the experiment stations for the year ended June 30, 1950*

Station	Date of legislative assent to Hatch Act	Date of organization under Hatch Act	Personnel					Publications					
			Full-time research	Research and teaching	Research and extension	Research, teaching, and extension	Total research workers	Station publications		Articles in scientific journals		Miscellaneous publications	
			Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Pages*	*Number*	*Pages*	*Number*	*Pages*
Alabama	Feb. 27, 1889	Apr. 1, 1888	62	49		2	113	16	600	38	50	43	132
Alaska	May 2, 1929	May 1, 1931	15				15	3	96			1	185
Arizona	Mar. 19, 1889	July 1, 1889	32	41	1		74	7	236	18	112	32	232
Arkansas	Mar. 7, 1889	Apr. 2, 1888	34	60	1	1	96	16	616	3	13	3	36
California	Mar. 12, 1889	Mar. 13, 1888	124	290			414	13	854	474	7,548	327	3,597
Colorado	Mar. 25, 1889	Feb. 20, 1888	38	84		2	124	8	340	56	(1)	28	(1)
Connecticut:													
State	May 18, 1887	May 18, 1887	67				67	20	596	41	262	34	283
Storrs	do	Apr. 1, 1888	31	32	2	6	71	2	108	46	302	16	140
Delaware	Apr. 14, 1887	Feb. 21, 1888	17	15	4	4	40	9	147	19	25	44	151
Florida	June 7, 1887	Mar. 16, 1888	136	19	7	4	166	24	827	178	537	65	117
Georgia	Dec. 24, 1888	Feb. 18, 1888	109	20		1	130	38	756	11	43	9	18
Hawaii	Mar. 31, 1911	July 1, 1929	48	13	2	1	64	16	332	17	131		
Idaho	Jan. 23, 1891	Feb. 26, 1892	16	40		1	57	7	239	13	65	6	76
Illinois	May 11, 1887	Mar. 21, 1888	88	112	14	5	219	26	856	64	469	2	220
Indiana	Jan. 19, 1889	July 1, 1887	98	74	12	11	195	44	1,232	60	274	4	78
Iowa	Mar. 1, 1888	Feb. 17, 1888	99	150	29	12	290	22	1,432	68	716	12	192
Kansas	Mar. 3, 1887	Feb. 8, 1888	43	159			202	20	(1)	137	1,370	77	846
Kentucky	Feb. 20, 1888	Apr. 29, 1888	97	28	5	12	142	32	962	50	199	9	81
Louisiana	July 12, 1888	Apr. 5, 1887	108	56	1		165	9	462	82	328	52	615
Maine	Mar. 16, 1887	Feb. 16, 1888	35	23	1	1	60	13	600	9	51	11	211
Maryland	Mar. 6, 1888	Mar. 9, 1888	21	30	7	29	87	2	62	24	154	8	59
Massachusetts	Apr. 20, 1887	Mar. 2, 1888	84	20			104	14	285	47	225		
Michigan	Apr. 12, 1889	Feb. 26, 1888	81	119	8	8	216	17	929	119	597	7	614
Minnesota	Feb. 4, 1889	Jan. 26, 1888	38	155	5	4	202	10	348	76	676	40	176
Mississippi	Jan. 31, 1888	Spring, 1888	66	36	1	3	106	16	334	40	370	26	120
Missouri	June 11, 1889	Jan. 31, 1888	17	126		4	147	44	1,339	63	(1)		
Montana	Feb. 16, 1893	July 1, 1893	35	41	1	13	90	9	213	17	(1)	4	52
Nebraska	Mar. 31, 1887	June 14, 1887	55	67			122	10	715	30	(1)	27	54
Nevada	Feb. 8, 1889	Dec., 1887	18			1	19	3	226				
New Hampshire	Aug. 4, 1887	Feb. 22, 1888	11	48	1	5	65	8	203	3	12	4	54

New Jersey	Mar. 16, 1887	Mar. 5, 1888	58	72	2	2	134	24	480	64	486	29	1,072
New Mexico	Feb. 28, 1889	Nov. 14, 1889	27	28	1	1	57	7	220	5	20	9	93
New York:													
Cornell	Mar. 30, 1887	Apr. 30, 1888	46	154	9	29	238	22	1,508	444	2,061	84	1,851
State	(2)		70				70	7	279	32	(1)	4	64
North Carolina	Mar. 7, 1887	Dec. 5, 1889	99	78	1	4	182	15	454	30	(1)	3	68
North Dakota	Mar. 8, 1890	Oct. 15, 1890	44	36			80	6	310	41	156	23	347
Ohio	Mar. 16, 1887	Apr. 2, 1888	112	56	2	3	173	22	772	96	449	7	156
Oklahoma	Oct. 27, 1890	Aug. 14, 1891	67	88	2		157	16	345	68	239	32	488
Oregon	Feb. 25, 1889	July 2, 1888	147	87	4	3	241	64	1,585	42	336		
Pennsylvania	June 3, 1887	June 30, 1887		216			216	37	763	58	326	8	30
Puerto Rico	Aug. 16, 1933	Nov. 14, 1935	83				83	4	165	7	51	18	493
Rhode Island	Mar. 31, 1887	Nov. 3, 1888	18	14		6	38	4	252	9	56		
South Carolina	Dec. 22, 1887	Jan., 1888	85	23	3	1	112	15	672	9	79		
South Dakota	Mar. 11, 1887	Nov. 17, 1887	34	41		1	76	22	588	17	(1)	12	176
Tennessee	Mar. 29, 1887	July 24, 1887	82	41		8	131	8	502	25	96	20	737
Texas	Apr. 2, 1887	Jan. 25, 1888	197	66	2	12	277	16	912	123	1,282	98	970
Utah	Mar. 8, 1888	Nov. 6, 1889	45	48	1	3	97	4	150	22	120	6	100
Vermont	Nov., 1888	Feb. 28, 1888	6	21	4	13	44	10	255	13	58	5	54
Virginia	Feb. 29, 1888	June 13, 1888	107	15	4	5	131	24	652	62	260		
Washington	Mar. 9, 1891	May 1, 1891	114	77			191	36	510	157	900		
West Virginia	Feb. 22, 1889	June 11, 1888	24	59	1	3	87	7	143	10	61		
Wisconsin	(3)	July 1, 1887	80	107	4	19	210	10	414	250	(1)		
Wyoming	Jan. 10, 1891	Mar. 27, 1891	24	31		1	56	10	224	10	25	7	47
Total			3,292	3,265	142	244	6,943	868	28,100	3,397	21,590	1,256	15,085

(1) Total pages unknown.
(2) First made eligible to receive part of the State allotment of Federal funds by legislative act approved May 12, 1894.
(3) Session of 1887.

TABLE 2.—*Federal funds available to the experiment stations for the year ended June 30, 1950*

Station	Federal-grant funds [1]							Contractual Federal funds, Research and Marketing, Title II			Total Federal funds available
			Research and Marketing, Title I								
			Sections 9(b)1 and 9(b)2		Section 9(b)3		Total				
	Hatch, Adams, and Purnell [2]	Bankhead-Jones	Carry-over from 1949	1950 Appropriation	Carry-over from 1949	1950 Appropriation		Carry-over from 1949	1950 Allotment	Total	
Alabama	$90,000	$96,152.81	$2,922.07	$118,337.56	$423.40	$17,500	$325,335.84	$7,700.00	$9,500	$17,200.00	$342,535.84
Alaska	42,500	2,627.86		20,920.04			66,047.90				66,047.90
Arizona	90,000	15,499.36	192.69	31,490.04		13,050	150,232.09				150,232.09
Arkansas	90,000	74,312.76	16,024.93	98,754.70	3,717.83	24,900	307,710.22				307,710.22
California	90,000	95,542.61	10,002.49	91,417.48	7,664.78	19,300	313,927.36	270.00	1,800	2,070.00	315,997.36
Colorado	90,000	26,055.98	8,257.85	41,742.64	4,651.54	75,225	245,933.01				245,933.01
Connecticut:											
State	45,000	13,129.28	2,273.60	18,045.38			78,448.26				78,448.26
Storrs	45,000	13,129.28	3,962.58	18,045.38	576.93	13,900	94,614.17		7,000	7,000.00	101,614.17
Delaware	90,000	6,054.94	9,341.86	24,301.46	2,250.00		131,948.26				131,948.26
Florida	90,000	40,579.22	2,308.83	50,946.22	3,385.49	10,945	198,164.76		10,000	10,000.00	208,164.76
Georgia	90,000	101,476.80	864.78	120,955.28	1,337.79	32,050	346,684.65	5,000.00	24,200	29,200.00	375,884.65
Hawaii	90,000	10,269.39	9,302.89	28,450.40			138,022.68		6,000	6,000.00	144,022.68
Idaho	90,000	16,589.81	1,191.34	35,604.96	52.06	25,000	168,438.17				168,438.17
Illinois	90,000	100,946.87	35,727.80	105,872.66	19,055.36	30,100	381,702.69		7,200	7,200.00	388,902.69
Indiana	90,000	73,383.88	11,327.47	87,106.72	13,497.20	47,650	322,965.27		32,000	32,000.00	354,965.27
Iowa	90,000	74,752.37		89,887.30	5,785.98	70,050	330,475.65	2,971.46	21,000	23,971.46	354,447.11
Kansas	90,000	57,178.54	320.71	67,623.70	895.58	15,950	231,968.53		10,000	10,000.00	241,968.53
Kentucky	90,000	95,122.25	14,415.71	115,404.96	104.81	9,425	324,472.73				324,472.73
Louisiana	90,000	65,919.96	20,858.50	85,178.44	7,274.10	17,700	286,931.00				286,931.00
Maine	90,000	24,124.05	3,000.00	37,979.00		24,600	179,703.05	4,000.00	7,500	11,500.00	191,203.05
Maryland	90,000	35,303.01	1,503.25	46,055.54	1,449.79	13,850	188,161.59		2,600	2,600.00	190,761.59
Massachusetts	90,000	21,787.39		35,751.10		16,700	164,238.49				164,238.49
Michigan	90,000	85,827.73	7,271.05	95,112.60	6,675.50	24,150	309,036.88	7,036.58	32,200	39,236.58	348,273.46
Minnesota	90,000	66,813.91	36,314.34	88,077.22	8,466.12	27,800	317,471.59				317,471.59
Mississippi	90,000	84,569.98	21,411.29	115,794.68	4,050.48	42,650	358,476.43	4,819.13	32,600	37,419.13	395,895.56
Missouri	90,000	89,383.63	5,009.01	106,039.24	7,345.65	22,950	320,727.53				320,727.53
Montana	90,000	17,871.46	1,138.22	34,513.38	565.62	15,950	160,038.68				160,038.68
Nebraska	90,000	44,233.72	2,858.14	57,743.04	3,109.73	19,600	217,544.63				217,544.63
Nevada	90,000	3,190.40		21,738.58		6,800	121,728.98				121,728.98
New Hampshire	90,000	9,925.30		27,101.98		4,300	131,327.28				131,327.28

New Jersey	90,000	36,470.37		42,398.00	7,451.82	21,800	198,120.19		6,000	6,000.00	204,120.19
New Mexico	90,000	16,935.36	11,948.22	34,773.18	3,383.88	18,300	175,340.64				175,340.64
New York:											
Cornell	81,000	99,202.17	22,038.96	90,622.73	17,873.09	68,450	379,186.95	3,000.00	7,300	10,300.00	389,486.95
State	9,000	11,022.46	2,013.29	10,069.19			32,104.94	6,349.56	10,000	16,349.56	48,454.50
North Carolina	90,000	123,766.51	14,760.11	145,018.08	7,044.01	44,950	425,538.71				425,538.71
North Dakota	90,000	28,147.42	2,362.03	44,318.38	2,676.37	4,400	171,904.20				171,904.20
Ohio	90,000	109,337.26	59,733.87	114,946.50	2,447.54	19,800	396,265.17		10,700	10,700.00	406,965.17
Oklahoma	90,000	78,367.16	3,379.97	89,931.48	6,501.63	11,000	279,180.24		5,000	5,000.00	284,180.24
Oregon	90,000	26,588.72	6,967.28	42,547.16	5,330.42	41,350	212,783.58	6,000.00		6,000.00	218,783.58
Pennsylvania	90,000	157,876.48		130,364.04	5,090.57	33,795	417,126.09				417,126.09
Puerto Rico	90,000	62,082.14	6,074.60	92,283.74		3,500	253,940.48		10,000	10,000.00	263,940.48
Rhode Island	90,000	2,857.19	984.37	21,643.08	1,196.45	23,400	140,081.09				140,081.09
South Carolina	90,000	69,224.19	13,099.39	88,855.84	675.42	34,445	296,299.84				296,299.84
South Dakota	90,000	27,733.01	4,858.18	42,917.76	3,846.30	15,900	185,255.25				185,255.25
Tennessee	90,000	89,992.09	528.88	113,618.52	380.40	27,850	322,369.89		1,300	1,300.00	323,669.89
Texas	90,000	173,212.81	2,206.20	185,536.50	508.98	64,800	516,264.49	4,015.73	18,500	22,515.73	538,780.22
Utah	90,000	12,170.15	135.99	29,309.12	6,476.76	40,250	178,342.02				178,342.02
Vermont	90,000	12,078.01	7,198.80	29,190.60	137.17	6,150	144,754.58				144,754.58
Virginia	90,000	82,941.86	14,462.82	98,338.98		18,215	303,958.66				303,958.66
Washington	90,000	38,797.09	1,533.61	51,558.50	2,154.73	39,900	223,943.93		14,750	14,750.00	238,693.93
West Virginia	90,000	65,169.05	20,612.44	71,672.80	2,495.45	21,800	271,749.74		2,500	2,500.00	274,249.74
Wisconsin	90,000	70,152.59	8,586.46	88,024.64	2,555.90	28,850	288,169.59	773.33	2,500	3,273.33	291,442.92
Wyoming	90,000	7,829.36	9,400.71	26,069.34	3,280.91	13,100	149,680.32				149,680.32
Total	4,542,500	2,863,708.00	440,687.58	3,599,999.84	183,843.54	1,244,100	12,874,838.96	51,935.79	292,150	344,085.79	13,218,924.75

[1] Includes unexpended balances from the previous year as follows:
Hatch—Connecticut (State), $1.22; Maryland, $133.42; New York (Cornell), $5.57; New York (State), $0.98; Vermont, $108.54.
Adams—Connecticut (State), $0.68; Delaware, $552.05; Hawaii, $114.09; Indiana, $5.47; New York (State), $16.19; Washington, $642.68.
Purnell—Arkansas, $745.50; Connecticut (State), $44.32; Indiana, $1,108.20; Maryland, $20.73; New York (Cornell), $60.32; Puerto Rico, $1,336.80; Texas, $0.05; Vermont, $475.16; Washington, $214.11.
Bankhead-Jones—Arkansas, $130.93; Connecticut (State), $466.82; New York (Cornell), $1.59; New York (State), $72.15; Ohio, $0.89; Puerto Rico, $482.04; Texas, $0.39; Vermont, $43.74; Washington, $1.85.

[2] Hatch, $15,000 for each State, Alaska, Hawaii, and Puerto Rico. Adams, $15,000 for each State, Hawaii, and Puerto Rico; $7,500 for Alaska. Purnell, $60,000 for each State, Hawaii, and Puerto Rico; $20,000 for Alaska.

TABLE 3.—*Non-Federal funds available to the experiment stations for the year ended June 30, 1950*

Station	State appropriations	Special endowments, industrial fellowships, etc.	Fees	Sales	Miscellaneous	Balance from previous year	Total
Alabama	$533,500.00	$110,189.15		$404,177.84	$3,702.84	$274,277.62	$1,325,847.45
Alaska	75,000.00			27,880.12		19,464.26	122,344.38
Arizona	284,103.26	21,383.64		38,316.25			343,803.15
Arkansas	385,000.00	12,818.92		191,413.52		32,185.70	621,418.14
California	4,074,559.02	134,708.95		173,738.19		239,131.55	4,622,137.71
Colorado	273,775.88	143,996.15		99,572.27	2,645.24	89,757.27	609,746.81
Connecticut:							
State	404,604.92	18,767.00					423,371.92
Storrs	483,735.35	24,325.63					508,060.98
Delaware	103,612.58			102,621.77	21,270.10	29,621.08	257,125.53
Florida	2,341,771.00	71,399.40		194,279.98	79,424.58	101,564.54	2,788,439.50
Georgia	141,274.00	39,034.16	$6,708.00	66,476.59	25,639.60	83,458.22	362,590.57
Hawaii	423,408.22	9,780.55		46,035.99	15,710.88	1,631.90	496,567.54
Idaho	443,445.72	36,641.34		63,930.46		43,021.66	587,039.18
Illinois	1,235,341.60	120,632.95		274,048.27			1,630,022.82
Indiana	832,000.00	165,611.52	163,706.32	602,320.96	64,959.23	553,595.84	2,382,193.87
Iowa	825,000.00	274,374.15		444,381.97		306,818.43	1,850,574.55
Kansas	437,351.49			199,856.52	65,899.01	81,661.90	784,768.92
Kentucky	314,935.16		277,099.05	60,000.00			652,034.21
Louisiana	908,931.42	384,460.01					1,293,391.43
Maine	213,997.29			31,530.26	8,995.61	35,459.33	289,982.49
Maryland	281,217.00	55,317.07		76,416.58		70,659.89	483,610.54
Massachusetts	431,165.87	13,917.50			31,447.16		476,530.53
Michigan	865,381.75			44,222.60		75,677.81	985,282.16
Minnesota	1,166,198.07	108,208.65	10,906.08	295,935.80			1,581,248.60
Mississippi	669,021.82	58,675.57		351,537.16	20,445.89	133,969.65	1,233,650.09
Missouri	198,375.00	44,027.02	136,232.73	103,751.30		250,845.27	733,231.32
Montana	422,948.00	16,201.25		270,759.43		150,633.59	860,542.27
Nebraska	432,310.05			480,531.48			912,841.53
Nevada	20,190.40			29,035.65		11,487.72	60,713.77
New Hampshire	43,535.72			7,023.91		7,285.23	57,844.86
New Jersey	680,940.58	320,287.57				5,885.81	1,007,113.96
New Mexico	184,300.00			54,533.48		60,057.66	298,891.14

New York:							
Cornell	1,863,960.87			326,409.64	8,178.29		2,198,548.80
State	756,790.95			28,423.57			785,214.52
North Carolina	1,049,003.41			97,581.60	64,244.83		1,210,829.84
North Dakota	542,329.88	37,641.22		107,252.62		75,427.62	762,651.34
Ohio	1,061,845.09			176,011.87		720,600.36	1,958,457.32
Oklahoma	701,298.00	23,035.10		202,178.97		177,567.92	1,104,079.99
Oregon	942,843.59	63,581.73	157,615.26	136,888.39			1,300,928.97
Pennsylvania	482,370.52	117,422.19		125,251.76	213,723.29	56,061.17	994,828.93
Puerto Rico	490,250.00				109,675.00	220,982.28	820,907.28
Rhode Island	47,671.52	13,587.50		26,641.05		22,245.91	110,145.98
South Carolina	371,623.72	7,781.78		59,842.66		35,157.34	474,405.50
South Dakota	181,161.00	5,474.97		93,869.92		27,926.10	308,431.99
Tennessee	324,299.62	66,569.30		175,063.18			565,932.10
Texas	1,126,049.24	182,867.25		992,415.74	93,763.64	524,295.50	2,919,391.37
Utah	290,000.00	21,019.56		56,305.52	22,458.33	16,616.02	406,399.43
Vermont	53,099.94			5,438.04	17,380.00	12,854.53	88,772.51
Virginia	583,510.29			74,307.82		108,444.42	766,262.53
Washington	1,210,794.56	85,833.71		164,497.29			1,461,125.56
West Virginia	334,332.00	3,282.20		126,115.47		52,106.56	515,836.23
Wisconsin	1,098,516.00	431,979.00		364,075.00			1,894,570.00
Wyoming	253,010.82			95,687.18		72,071.96	420,769.96
Total	33,895,692.19	3,244,833.66	752,267.44	8,168,585.64	869,563.52	4,780,509.62	51,711,452.07

TABLE 4.—*Expenditures and appropriations under the Hatch Act (Mar. 2, 1887)[1] for the year ended June 30, 1950*

Station	Expenditures												Unexpended	Appropriation
	Personal Services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and reproduction	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Total expenditures		
Alabama	$14,007.05	$111.31	$81.47	$127.98	$75.00	$19.80		$399.04	$178.35			$15,000.00		$15,000
Alaska	12,955.97					14.37	$6.50	680.12	1,343.04			15,000.00		15,000
Arizona	14,705.88	86.31			99.90	28.71		79.20				15,000.00		15,000
Arkansas	9,481.05	139.41			50.00	1,560.15	79.72	1,882.44	1,639.73		$167.50	15,000.00		15,000
California	15,000.00											15,000.00		15,000
Colorado	7,584.37	812.70	.75	205.39		1,373.91	2,646.25	355.05	1,655.35		366.23	15,000.00		15,000
Connecticut:														
State	5,625.00							1,836.80				7,461.80	$38.20	7,500
Storrs	5,497.17	306.56				20.50	69.64	6.35	1,599.78			7,500.00		7,500
Delaware	10,799.81	59.80	4.08	1,381.32		935.25	102.60	844.21	872.93			15,000.00		15,000
Florida	15,000.00											15,000.00		15,000
Georgia	12,310.72		1.62			333.56	61.35	1,152.62	1,140.13			15,000.00		15,000
Hawaii	15,000.00											15,000.00		15,000
Idaho	6,263.92	1,988.60	220.86	364.05		2,958.01	143.80	1,180.20	1,880.56			15,000.00		15,000
Illinois	14,477.47										522.53	15,000.00		15,000
Indiana	15,000.00											15,000.00		15,000
Iowa	10,566.93	8.26	175.24	172.64		3,770.37	6.77	299.79				15,000.00		15,000
Kansas	13,577.97	511.38		10.01	35.39	28.22	257.58	540.52	38.93			15,000.00		15,000
Kentucky	14,147.20	93.15				759.65						15,000.00		15,000
Louisiana	13,603.19	82.16		97.68		425.00	42.23	689.74	60.00			15,000.00		15,000
Maine	11,023.56	870.38	82.53	81.70	482.78	305.88	5.00	1,674.78	473.39			15,000.00		15,000
Maryland	7,556.22	2,878.63	1.13	34.29	33.15	100.00	1,723.65	1,739.29	933.64			15,000.00		15,000
Massachusetts	12,452.84	635.56					300.00	33.13	1,578.47			15,000.00		15,000
Michigan	7,200.00					7,800.00						15,000.00		15,000
Minnesota	12,627.24	623.59		54.27		50.15	193.40	537.98	644.45		268.92	15,000.00		15,000
Mississippi	12,495.88	384.78	3.69	338.64	113.66	16.20	24.74	1,142.59	477.59	2.23		15,000.00		15,000
Missouri	12,649.84	81.02			5.00		57.79	1,134.23	711.56	15.46	345.10	15,000.00		15,000
Montana	14,011.06	224.04	7.41				6.40	751.09				15,000.00		15,000
Nebraska	15,000.00											15,000.00		15,000
Nevada	12,625.00	234.65	3.11	308.05	177.61	467.90	31.15	843.40	39.13		270.00	15,000.00		15,000

New Hampshire	12,708.24	126.73	17.35	388.53	1,100.00	186.45	.55	322.15	150.00			15,000.00		15,000
New Jersey	13,071.50	57.83	2.86		18.51		52.00	383.39	1,413.91			15,000.00		15,000
New Mexico	13,137.49	641.38	54.67	23.80	292.18		227.42	402.80	220.26			15,000.00		15,000
New York:														
Cornell	11,868.20	14.20			71.20		508.58	337.01	700.79			13,499.98	.02	13,500
State	1,048.91						16.63		425.73			1,491.27	8.73	1,500
North Carolina	12,763.86	501.84		10.19		347.25	172.58	988.96	215.32			15,000.00		15,000
North Dakota	14,296.49			57.80				28.21			617.50	15,000.00		15,000
Ohio	12,213.00	773.60		3.86		652.00	88.65	860.64	408.25			15,000.00		15,000
Oklahoma	13,227.93	1,406.40						365.67				15,000.00		15,000
Oregon	13,436.06	1,423.31		1.12			6.20	8.15	125.16			15,000.00		15,000
Pennsylvania	7,951.29	516.33	1.53		9.00	6,178.87		268.34	74.64			15,000.00		15,000
Puerto Rico	12,530.90	282.61		44.03				1,253.25	889.21			15,000.00		15,000
Rhode Island	7,383.75	941.32	38.82	916.95		98.79	324.30	4,022.91	1,273.16			15,000.00		15,000
South Carolina	12,194.05	112.32	10.19	239.43		1,089.78	109.95	773.56	470.72			15,000.00		15,000
South Dakota	6,543.16	650.75	67.92	13.80	6.00	2,912.83	269.11	3,006.24	1,530.19			15,000.00		15,000
Tennessee	14,990.81		9.19									15,000.00		15,000
Texas	9,649.00	1,404.01	5.73	60.71			510.35	1,922.57	1,447.63			15,000.00		15,000
Utah	12,752.02					2,247.28		.70				15,000.00		15,000
Vermont	9,022.65	457.94	44.40	959.34	1,374.57	2,282.17	201.16	388.24	72.53		197.00	15,000.00		15,000
Virginia	14,873.74	22.10		77.20				16.00	10.96			15,000.00		15,000
Washington	14,447.63	57.63				3.00	405.25	86.49				15,000.00		15,000
West Virginia	12,297.32	12.88			846.55	457.67	214.98	97.01	1,073.59			15,000.00		15,000
Wisconsin	9,127.19	45.66			460.47	36.52	369.79	1,415.92	3,544.45			15,000.00		15,000
Wyoming	13,588.40	275.60		5.99		1,117.51	12.50					15,000.00		15,000
Total	618,368.93	19,856.73	834.55	5,978.77	5,250.97	38,577.75	9,248.57	34,750.78	29,313.53	17.69	2,754.78	764,953.05	46.95	765,000

[1] Extended to Hawaii by act of May 16, 1928; to Alaska by act of February 23, 1929; and to Puerto Rico by act of March 4, 1931.

TABLE 5.—*Expenditures and appropriations under the Adams Act (Mar. 16, 1906)[1] for the year ended June 30, 1950*

Station	Expenditures											Unexpended	Appropriation
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Total expenditures		
Alabama	$11,319.35	$303.72	$15.51	$11.10	$405.85	$71.70	$967.91	$1,904.86			$15,000.00		$15,000
Alaska	5,548.78	57.50	21.84			13.50	521.69	1,336.69			7,500.00		7,500
Arizona	12,341.00	1,116.53	58.65	52.53		657.85	573.66	199.78			15,000.00		15,000
Arkansas	11,128.75	759.04	5.21		30.00	356.83	1,110.71	1,111.71		$497.75	15,000.00		15,000
California	15,000.00										15,000.00		15,000
Colorado	12,631.43	235.80	166.24	6.25	53.47	374.38	818.81	314.12	$75.95	323.55	15,000.00		15,000
Connecticut:													
State	7,500.00										7,500.00		7,500
Storrs	7,500.00										7,500.00		7,500
Delaware	11,848.50	468.38	4.63	1.20	26.90	294.29	1,058.65	993.82			14,696.37	$303.63	15,000
Florida	15,000.00										15,000.00		15,000
Georgia	14,522.84	7.50	18.26	10.37		53.69	335.99	51.35			15,000.00		15,000
Hawaii	15,000.00										15,000.00		15,000
Idaho	11,935.26	519.63	5.45	25.34		204.53	1,455.43	854.36			15,000.00		15,000
Illinois	10,655.30		6.21			224.29	1,647.61	2,100.55		366.04	15,000.00		15,000
Indiana	13,184.63			2.48		79.63	1,733.26				15,000.00		15,000
Iowa	15,000.00										15,000.00		15,000
Kansas	12,362.39		3.56		7.60	59.50	1,888.94	678.01			15,000.00		15,000
Kentucky	15,000.00										15,000.00		15,000
Louisiana	11,621.34	325.03	6.30	1.50		489.39	1,247.49	1,308.95			15,000.00		15,000
Maine	13,605.04	1.65	10.86			7.05	930.72	444.68			15,000.00		15,000
Maryland	11,468.00	23.41	13.18	13.80		46.50	2,143.19	1,291.92			15,000.00		15,000
Massachusetts	15,000.00										15,000.00		15,000
Michigan	15,000.00										15,000.00		15,000
Minnesota	13,588.10	125.45	2.56			84.91	422.09	496.61		280.28	15,000.00		15,000
Mississippi	12,283.69	274.90	58.44	9.71	230.38	678.87	1,180.04	229.45	54.52		15,000.00		15,000
Missouri	12,129.46		17.56		37.20	425.82	1,699.77	446.29		243.90	15,000.00		15,000
Montana	13,350.60	502.16	3.48	2.45		41.74	1,092.18	7.39			15,000.00		15,000
Nebraska	15,000.00										15,000.00		15,000
Nevada	12,320.50	140.65	8.00	5.23	58.10	26.35	740.48	1,205.19		495.50	15,000.00		15,000
New Hampshire	13,272.34	5.00	33.20	56.30		30.64	1,096.52	506.00			15,000.00		15,000

New Jersey	13,548.83	106.27	7.69		78.85	45.15	713.26	499.95			15,000.00		15,000
New Mexico	12,616.15		7.06		163.71	356.10	1,307.83	483.20	65.95		15,000.00		15,000
New York:													
Cornell	7,601.05		71.40			26.64	2,927.43	2,873.48			13,500.00		13,500
State	35.00						234.35	1,224.40			1,493.75	6.25	1,500
North Carolina	12,406.85	76.20					338.00	2,178.95			15,000.00		15,000
North Dakota	14,225.89			1.22		17.21	300.93	50.50		404.25	15,000.00		15,000
Ohio	13,470.00		14.13				909.57	606.30			15,000.00		15,000
Oklahoma	9,330.56	154.79				375.12	3,323.29	1,816.24			15,000.00		15,000
Oregon	14,633.60			.19	1.22		123.54	241.45			15,000.00		15,000
Pennsylvania	15,000.00										15,000.00		15,000
Puerto Rico	9,764.19	380.38	47.39		10.90	257.21	1,809.04	2,730.89			15,000.00		15,000
Rhode Island	13,334.83	97.42	9.76				1,381.99	176.00			15,000.00		15,000
South Carolina	13,240.70	346.10		27.85		69.50	824.17	491.68			15,000.00		15,000
South Dakota	13,628.17	328.55	52.35	3.76		74.02	913.15				15,000.00		15,000
Tennessee	14,736.03		2.37	3.61	24.97	125.00		108.02			15,000.00		15,000
Texas	13,638.28	21.50		.85		584.74	137.78	616.85			15,000.00		15,000
Utah	15,000.00										15,000.00		15,000
Vermont	11,773.66	178.59	34.99	2.43	59.27	239.26	1,290.23	942.82		478.75	15,000.00		15,000
Virginia	14,163.76	7.95			6.00	229.90	183.63	408.76			15,000.00		15,000
Washington	12,143.85	290.22	19.36			98.87	1,651.82	795.88			15,000.00		15,000
West Virginia	13,175.00					27.00	1,273.22	524.78			15,000.00		15,000
Wisconsin	10,579.15		131.20				4,289.65				15,000.00		15,000
Wyoming	13,520.00	299.00					1,181.00				15,000.00		15,000
Total	657,682.85	7,153.32	856.84	238.17	1,194.42	6,747.18	47,779.02	32,251.88	196.42	3,090.02	757,190.12	309.88	757,500

[1] Extended to Hawaii by act of May 16, 1928; to Puerto Rico by act of March 4, 1931; and to Alaska by act of June 30, 1936.

TABLE 6.—*Expenditures and appropriations under the Purnell Act (Feb. 24, 1925)[1] for the year ended June 30, 1950*

Station	Expenditures												Unexpended	Appropriation
	Personal Services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and reproduction	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Total expenditures		
Alabama	$45,367.02	$797.14	$301.79	$204.88	$1,276.60	$1,556.99	$404.12	$4,120.80	$5,970.66			$60,000.00		$60,000
Alaska	15,359.66							557.96	3,802.43	$279.95		20,000.00		20,000
Arizona	43,147.82	2,525.66	328.71	116.15		22.17	2,409.69	9,345.24	2,104.56			60,000.00		60,000
Arkansas	44,455.15	1,215.76			407.20	2,152.02	1,185.78	4,507.87	4,545.57		$1,306.05	59,775.40	$224.60	60,000
California	60,000.00											60,000.00		60,000
Colorado	47,128.93	2,284.73	26.65	152.45	411.44	128.62	707.52	4,766.67	2,448.39		1,944.60	60,000.00		60,000
Connecticut:														
State	22,470.00	199.66	2.81			1,847.33	709.99	1,501.16	2,492.39	736.02		29,959.36	40.64	30,000
Storrs	27,172.75	835.47	27.16		40.30	60.00	219.40	605.89	1,029.92			29,990.89	9.11	30,000
Delaware	50,102.76	2,048.42	16.01	23.53	30.54	1,080.38	656.37	4,307.58	1,734.41			60,000.00		60,000
Florida	60,000.00											60,000.00		60,000
Georgia	51,407.15	1,624.26	130.93	1.35		356.85	538.33	3,539.86	2,401.27			60,000.00		60,000
Hawaii	53,146.74						1,120.55	86.04	675.00	4,923.00		59,951.33	48.67	60,000
Idaho	44,247.89	2,610.69	15.33	2.28		6.20	45.46	10,060.37	2,937.69	74.09		60,000.00		60,000
Illinois	51,844.99	1,139.63	15.73			533.03	1,070.75	3,733.46	131.27		1,531.14	60,000.00		60,000
Indiana	51,743.47	1,725.66	25.07	23.22			349.96	2,313.06	3,819.56			60,000.00		60,000
Iowa	59,723.86					.90		275.24				60,000.00		60,000
Kansas	55,343.11	815.51		143.33			388.17	2,068.36	1,241.52			60,000.00		60,000
Kentucky	52,349.92	3,467.70	43.11	18.45		1,878.99	44.91	981.62	1,215.30			60,000.00		60,000
Louisiana	48,863.70	2,621.96	132.83	82.79	690.87		2,652.58	3,263.65	1,475.77	215.85		60,000.00		60,000
Maine	44,828.52	2,396.08	72.73	2.38	1,771.60	738.18	525.91	8,537.20	1,127.40			60,000.00		60,000
Maryland	50,479.22	1,498.82	28.49	77.37	65.45	31.45	515.83	5,685.78	1,617.59			60,000.00		60,000
Massachusetts	53,149.73	847.25					309.00	2,964.90	2,729.12			60,000.00		60,000
Michigan	59,717.15		3.68			9.96	9.36	259.85				60,000.00		60,000
Minnesota	52,287.15	2,015.28	54.59	78.85	5.00	263.35	899.41	1,561.38	2,206.78		628.21	60,000.00		60,000
Mississippi	47,226.97	1,245.93	143.48	422.56	472.07	1,075.60	1,630.79	6,439.81	1,342.79			60,000.00		60,000
Missouri	42,603.04	962.97	114.27	11.05	137.55	180.76	1,417.58	8,097.27	5,389.41		1,086.10	60,000.00		60,000
Montana	50,313.48	1,834.64	15.87	115.86	96.53	1,402.62	739.80	4,607.63	873.57			60,000.00		60,000
Nebraska	54,264.67	432.69	2.00	.09	51.85	925.06	125.98	3,923.85	273.81			60,000.00		60,000
Nevada	39,865.26	1,115.46	57.87	402.02	1,280.68	2,807.75	172.29	12,876.26	756.66		665.75	60,000.00		60,000
New Hampshire	51,747.88	1,127.75	42.18	31.42	178.00	509.60	232.37	2,827.58	3,303.22			60,000.00		60,000

New Jersey	49,395.86	1,024.46	36.06		1,003.01		404.44	6,151.98	1,984.19			60,000.00		60,000
New Mexico	48,168.67	2,020.31	48.90	73.68	1,449.87	46.51	779.34	5,330.27	2,082.45			60,000.00		60,000
New York:														
Cornell	49,204.12	937.59	24.46	12.87	29.34	133.20	557.73	1,873.53	1,054.96			53,827.80	172.20	54,000
State	4,923.00		21.40				100.00	193.74	760.43			5,998.57	1.43	6,000
North Carolina	45,715.00	3,023.73	7.66	207.97		70.20	459.83	4,684.07	5,831.54			60,000.00		60,000
North Dakota	53,461.15	814.69	10.10	33.02	159.52		82.19	1,808.55	1,687.28		1,943.50	60,000.00		60,000
Ohio	49,400.58	1,715.94	30.09		264.00	133.60	476.80	4,203.29	3,775.70			60,000.00		60,000
Oklahoma	40,411.45	1,440.17	19.61		68.56	159.49	1,969.92	10,732.63	3,698.17	1,500.00		60,000.00		60,000
Oregon	52,501.71	2,009.98	8.94	223.25	14.43	90.29	164.02	1,484.88	3,502.50			60,000.00		60,000
Pennsylvania	53,614.91	897.42	3.98			821.41	22.46	4,639.82				60,000.00		60,000
Puerto Rico	36,008.26	2,745.21	4.06		40.00	614.00	236.95	5,766.98	14,575.08			59,990.54	9.46	60,000
Rhode Island	48,905.52	328.34	12.90			479.00	28.00	8,239.15	2,007.09			60,000.00		60,000
South Carolina	46,813.08	797.14	25.34	219.33	415.28	2,068.42	1,397.40	3,461.56	4,802.45			60,000.00		60,000
South Dakota	42,738.15	2,683.62	120.01	171.93	186.52	3,905.12	800.91	6,836.13	2,557.61			60,000.00		60,000
Tennessee	57,323.49	66.64	90.40	7.00	30.94		62.87	1,641.06	448.54	329.06		60,000.00		60,000
Texas	48,600.80	392.00	25.85	27.77	431.42	19.31	4,057.19	3,096.37	3,074.10	275.14		59,999.95	.05	60,000
Utah	52,299.74	2,557.91	55.03		12.50	5.00	406.06	3,518.01	1,145.75			60,000.00		60,000
Vermont	49,387.56	2,332.08	21.31	51.01	45.45		730.32	2,629.83	3,665.80		1,039.33	59,902.69	97.31	60,000
Virginia	53,872.31	1,306.85	6.11	65.80	55.80	1,811.00	393.40	1,611.99	876.74			60,000.00		60,000
Washington	46,005.68	1,074.90	143.59	58.63		307.59	1,096.81	5,348.71	5,964.09			60,000.00		60,000
West Virginia	49,893.02		504.87		1,110.94	461.64	697.07	5,081.26	2,251.20			60,000.00		60,000
Wisconsin	56,439.96	1,042.48	30.19	21.01		672.48	58.15	1,533.03	202.70			60,000.00		60,000
Wyoming	57,823.00	282.79				400.00		464.37	1,029.84			60,000.00		60,000
Total	2,523,265.01	66,883.37	2,852.15	3,083.30	12,233.26	29,766.07	34,063.76	204,147.55	124,624.27	8,333.11	10,144.68	3,019,396.53	603.47	3,020,000

[1]Extended to Hawaii by act of May 16, 1928; to Alaska by act of February 23, 1929; and to Puerto Rico by act of March 4, 1931.

TABLE 7.—*Expenditures and appropriations under the Bankhead-Jones Act (June 29, 1935)[1] for the year ended June 30, 1950*

Station	Expenditures												Unexpended	Appropriation
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and reproduction	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Total expenditures		
Alabama	$66,897.03	$2,352.79	$260.02	$182.57	$1,266.75	$2,000.41	$1,112.47	$13,904.23	$5,789.54	$2,387.00		$96,152.81		$96,152.81
Alaska	2,461.50	16.45						149.91				2,627.86		2,627.86
Arizona	12,386.41	1,201.27	3.52	89.91	8.00	3.00	178.84	1,499.76	128.65			15,499.36		15,499.36
Arkansas	49,736.48	2,290.96		1.75	164.00	909.79	2,277.31	5,478.15	11,653.53	577.26	$1,193.53	74,282.76	$30.00	74,312.76
California	95,542.61											95,542.61		95,542.61
Colorado	20,101.13	969.07	43.94	31.13	76.86	169.36	198.73	2,595.16	1,126.85		743.75	26,055.98		26,055.98
Connecticut:														
State	8,280.00	37.56					584.60	1,833.73	1,867.29	482.00		13,085.18	44.10	13,129.28
Storrs	8,760.00							1,860.81	2,165.20			12,786.01	343.27	13,129.28
Delaware	4,362.74	40.43	2.60			6.00		1,436.57	206.60			6,054.94		6,054.94
Florida	30,981.62	582.48	81.39	.27	142.84		33.89	6,508.78	2,247.95			40,579.22		40,579.22
Georgia	79,913.04	1,097.15	218.64	2.53	238.81	3.90	1,661.01	11,882.22	6,159.50	300.00		101,476.80		101,476.80
Hawaii	6,414.60								254.89	3,599.90		10,269.39		10,269.39
Idaho	8,367.41	808.74	22.48	52.90	9.00		498.32	2,736.32	629.91	3,464.73		16,589.81		16,589.81
Illinois	86,307.96	1,785.66	41.20	10.25		581.98	629.01	5,724.48	2,381.05		3,485.28	100,946.87		100,946.87
Indiana	64,598.80	733.81	65.00	18.36			421.42	5,524.79	2,006.08			73,368.26	15.62	73,383.88
Iowa	72,412.50							2,339.87				74,752.37		74,752.37
Kansas	47,790.57	401.74	.46		106.75		246.96	5,943.45	2,688.61			57,178.54		57,178.54
Kentucky	82,062.06	1,930.92	71.27	11.65		1,451.95	125.88	5,232.51	4,236.01			95,122.25		95,122.25
Louisiana	49,558.97	1,696.63	28.97	42.23			1,065.96	5,395.92	6,631.28	1,500.00		65,919.96		65,919.96
Maine	18,406.51	1,261.52	41.30	10.86	177.20	393.72	160.52	1,913.71	1,758.71			24,124.05		24,124.05
Maryland	23,446.42	136.29	150.27	80.35	144.43	112.60	121.47	9,605.67	1,500.24			35,297.74	5.27	35,303.01
Massachusetts	21,608.68							32.30		146.41		21,787.39		21,787.39
Michigan	81,203.70	482.41	49.02				785.57	1,989.79	1,317.24			85,827.73		85,827.73
Minnesota	47,341.15	2,152.35	165.82	76.25	77.50	634.07	1,276.55	7,562.96	7,122.05		405.21	66,813.91		66,813.91
Mississippi	57,931.53	1,537.64	208.55	365.58	1,360.90	1,282.86	2,127.85	13,253.49	3,315.74	3,185.84		84,569.98		84,569.98
Missouri	64,260.03	1,213.38	295.81	258.40	1,024.44	258.44	1,895.67	13,649.61	4,990.74	49.70	1,487.41	89,383.63		89,383.63
Montana	16,488.57	17.65	5.74				16.08	1,266.90	76.52			17,871.46		17,871.46
Nebraska	40,355.68	956.11	33.78			1,325.00	105.85	1,315.83	141.47			44,233.72		44,233.72
Nevada	2,449.42	199.96	26.12					168.14	283.91	33.60	29.25	3,190.40		3,190.40
New Hampshire	8,543.18	413.08	5.56	4.35		12.30	14.63	382.65	549.55			9,925.30		9,925.30

New Jersey	29,180.15	847.00	21.88		329.67	20.20	377.80	3,782.91	1,910.76			36,470.37		36,470.37
New Mexico	11,780.19		1.76	4.85	148.73		260.91	2,817.73	1,921.19			16,935.36		16,935.36
New York:														
Cornell	67,139.45	2,123.62	105.04	8.48		92.60	2,435.98	15,686.10	11,062.48	548.10		99,201.85	.32	99,202.17
State	8,719.12						60.25	828.37	1,388.21			10,995.95	26.51	11,022.46
North Carolina	93,057.95	3,817.06	170.35	628.66	302.60	85.79	2,492.70	11,566.05	11,645.35			123,766.51		123,766.51
North Dakota	25,005.33	290.54	3.28	9.31		38.95	185.80	969.87	824.84		819.50	28,147.42		28,147.42
Ohio	87,556.00	1,060.97	41.05		165.09	458.77	1,182.86	8,286.30	10,417.47	168.75		109,337.26		109,337.26
Oklahoma	48,870.58	1,912.63	48.11		139.26	12.16	933.03	18,969.11	7,482.28			78,367.16		78,367.16
Oregon	20,221.57	405.22	9.12	61.46	48.25	8.48	77.12	1,542.76	4,214.74			26,588.72		26,588.72
Pennsylvania	127,306.89	3,361.16	13.27	7.50	100.28	829.59	45.48	18,685.82	6,403.94	1,122.55		157,876.48		157,876.48
Puerto Rico	31,956.51	1,207.81	168.18		1,503.02		22.00	20,335.51	6,818.79			62,011.82	70.32	62,082.14
Rhode Island	2,458.88	38.93	10.51				225.00	123.87				2,857.19		2,857.19
South Carolina	52,560.29	320.07	205.63	204.38	613.67		4,603.82	7,397.29	3,319.04			69,224.19		69,224.19
South Dakota	18,398.14	729.77	116.11	31.90	.75	481.10	373.63	5,323.70	2,277.91			27,733.01		27,733.01
Tennessee	71,475.96	1,167.73	143.62	33.18	145.09		707.73	6,591.29	5,502.95	4,224.54		89,992.09		89,992.09
Texas	136,781.97	3,551.69	156.17	1.08	478.57	2,450.99	9,460.69	11,704.63	7,322.71	1,303.92		173,212.42	.39	173,212.81
Utah	11,318.85	418.80	3.26				94.47	137.21	197.56			12,170.15		12,170.15
Vermont	8,980.78	108.00	27.22	41.24	124.83		688.04	1,290.44	549.94		261.75	12,072.24	5.77	12,078.01
Virginia	76,274.50	875.84		411.31	7.86	440.00	206.35	3,971.20	754.80			82,941.86		82,941.86
Washington	27,734.16	210.63	84.60				458.77	6,602.42	3,706.51			38,797.09		38,797.09
West Virginia	54,361.66	1,794.52			1,193.88	106.39	196.66	5,333.93	2,182.01			65,169.05		65,169.05
Wisconsin	54,774.23	432.10					112.43	14,733.83	100.00			70,152.59		70,152.59
Wyoming	6,234.40	402.04	24.88				475.40	586.53	106.11			7,829.36		7,829.36
Total	2,251,117.86	49,392.18	3,175.50	2,682.69	10,099.03	14,170.40	41,215.51	298,454.58	161,338.70	23,094.30	8,425.68	2,863,166.43	541.57	2,863,708.00

TABLE 8.—*Expenditures and funds available under the Research and Marketing Act of 1946, Title I, Sections 9(b)1 and 9(b)2, for the year ended June 30, 1950*

Station	Expenditures												Unexpended balances [1]	Funds available [2]
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and reproduction	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Total expenditures		
Alabama	$56,751.09	$6,865.10	$275.99	$379.50	$1,508.91	$915.36	$1,064.49	$8,885.91	$8,200.61	$2,363.13		$87,210.09	$34,049.54	$121,259.63
Alaska	8,475.82	182.01	10.00					995.71	22.74			9,686.28	11,233.76	20,920.04
Arizona	19,511.58	4,342.71	56.61	159.75	10.27		690.75	3,988.99	2,062.56			30,823.22	859.51	31,682.73
Arkansas	46,535.24	7,675.13		275.27	205.38	470.84	2,367.47	9,009.80	21,419.12	2,919.17	$395.00	91,272.42	23,507.21	114,779.63
California	92,332.46		431.86				1,914.42	335.64	4,030.59			99,044.97	2,375.00	101,419.97
Colorado	28,417.56	590.78	56.95	66.25	188.58	69.40	457.60	3,092.62	5,304.18	703.12	980.49	39,927.53	10,072.96	50,000.49
Connecticut:														
State	7,369.99	213.06					937.37	600.68	4,743.99			13,865.09	6,453.89	20,318.98
Storrs	13,689.92	770.80						2,184.71	2,790.31			19,435.74	2,572.22	22,007.96
Delaware	19,460.90	2,307.85	15.01	3.85		213.45	262.84	867.56	1,457.08			24,588.54	9,054.78	33,643.32
Florida	38,458.90	2,105.14	18.22	0.52				1,869.05	1,417.54			43,869.37	9,385.68	53,255.05
Georgia	91,177.91	4,315.96	132.77	32.75	931.00	33.50	1,726.37	8,048.71	11,095.91			117,494.88	4,325.18	121,820.06
Hawaii	20,561.75	3,812.84	24.61				13.27	1,065.57	4,103.10			29,581.14	8,172.15	37,753.29
Idaho	6,942.51	2,231.27	552.70	231.92	129.85	307.53	1,172.79	7,033.94	5,243.81	3,991.85		27,838.17	8,958.13	36,796.30
Illinois	70,768.86	2,567.42	64.32	13.10		580.11	3,413.05	12,555.12	11,643.00		1,501.28	103,106.26	38,494.20	141,600.46
Indiana	68,748.24	1,161.42	55.48	6.35			262.04	11,001.75	7,398.71			88,633.99	9,800.20	98,434.19
Iowa	87,281.72	157.23	28.13	43.24	85.37	108.37	43.41	2,139.83				89,887.30		89,887.30
Kansas	54,204.44	2,219.76	53.20	2.53	15.00		1,389.11	5,935.38	3,367.90			67,187.32	757.09	67,944.41
Kentucky	78,069.34	7,744.54	132.24	582.83	30.00	572.43	11,316.03	11,506.82	6,462.38	2,350.26		118,766.87	11,053.80	129,820.67
Louisiana	51,697.57	5,136.64	272.40	84.29	700.86		776.01	7,022.62	10,786.78	6,779.33		83,256.50	22,780.44	106,036.94
Maine	22,854.67	3,011.59	43.90	94.00	50.14	669.52	532.50	3,228.63	4,008.36			34,493.31	6,485.69	40,979.00
Maryland	36,989.93	1,330.17	75.49	31.75	36.53	2.92	376.15	3,322.74	1,442.28			43,607.96	3,950.83	47,558.79
Massachusetts	15,963.94	3,537.58	2.99	28.95			976.20	3,638.39	8,319.28	3,343.77		35,751.10		35,751.10
Michigan	68,065.74	3,330.78	99.54	81.82	34.67	550.48	2,299.86	9,323.74	4,729.40			88,516.03	13,867.62	102,383.65
Minnesota	64,159.84	5,663.75	222.01	77.25		362.63	810.71	7,166.04	7,165.32			85,627.55	38,764.01	124,391.56
Mississippi	80,437.90	6,216.52	691.10	529.61	1,945.80	1,869.13	2,278.44	17,775.33	4,312.37	598.46		116,654.66	20,551.31	137,205.97
Missouri	71,120.04	2,725.95	452.16	169.20	390.00	231.14	5,863.00	8,245.63	16,447.59	425.00	1,325.91	107,395.62	3,652.63	111,048.25
Montana	28,217.57	811.89	23.67	4.93		18.52	1,096.16	2,523.76	1,419.86			34,116.36	1,535.24	35,651.60
Nebraska	49,144.06	2,564.62		.75			973.29	3,222.11	782.67			56,687.50	3,913.68	60,601.18
Nevada	10,529.92	1,669.98	355.48	140.75	333.35	32.16	·65.90	1,628.12	6,771.67		211.25	21,738.58		21,738.58
New Hampshire	23,987.70	968.84	2.47	7.30	10.00	24.80	54.96	903.67	1,142.24			27,101.98		27,101.98

New Jersey	20,975.04	1,289.86	261.39	1.20	192.00		1,735.67	3,217.65	12,703.52			40,376.33	2,021.67	42,398.00
New Mexico	26,198.39	2,316.86	16.95	102.42	154.60		192.76	6,088.33	1,297.47	3.85		36,353.63	10,367.77	46,721.40
New York:														
Cornell	57,146.42	14,669.45	120.12	145.17	2,098.74	393.27	6,842.95	13,507.94	8,447.77	630.34		104,002.17	8,659.52	112,661.69
State	4,708.31	64.98		51.10			311.43	878.81	2,807.49			8,822.12	3,260.36	12,082.48
North Carolina	98,511.83	2,274.58	352.57	281.70	104.00	142.80	418.39	13,032.48	21,446.55	11,115.97		147,680.87	12,097.32	159,778.19
North Dakota	30,894.43	1,778.24	82.87	32.40	99.92	1,889.00	474.10	4,793.13	1,555.46	38.95	657.00	42,295.50	4,384.91	46,680.41
Ohio	61,048.71	3,219.49	33.29	48.00	25.00	438.80	2,211.36	4,843.41	4,723.86	59.20		76,651.12	98,029.25	174,680.37
Oklahoma	52,842.16	2,228.04	93.16	87.89	43.95	3.50	1,956.46	6,905.77	17,072.01	1,206.00		82,438.94	10,872.51	93,311.45
Oregon	34,453.68	2,843.22	50.28	261.59	3.35	3.50	717.37	4,748.78	2,467.42			45,549.19	3,965.25	49,415.44
Pennsylvania	64,778.69	2,004.16	13.26	6.75		1,309.89	505.15	8,301.67	7,331.26	3,474.11		87,724.94	42,639.10	130,364.04
Puerto Rico	54,572.47	1,826.78	81.15		908.52	9.75	785.86	12,312.75	13,610.47			84,107.75	14,250.59	98,358.34
Rhode Island	11,477.14	227.22			197.07	240.00	31.65	3,287.01	1,215.00	2,284.80		18,959.89	3,667.56	22,627.45
South Carolina	56,803.42	4,886.52	74.53	196.85	91.82	1,015.89	2,781.55	11,323.17	6,378.86	770.74		84,323.35	17,631.88	101,955.23
South Dakota	22,359.79	3,819.76	18.19	15.00		839.06		2,747.81	5,000.00			34,799.61	12,976.33	47,775.94
Tennessee	83,564.69	3,970.43	176.75	41.20	32.81	17.00	1,006.76	4,585.52	8,431.53			101,826.69	12,320.71	114,147.40
Texas	134,728.84	7,665.85	86.43	230.13	179.10	930.76	10,784.79	17,874.20	12,498.18	1,130.47		186,108.75	1,633.95	187,742.70
Utah	17,625.70	84.56	106.94				234.20	8,823.76	938.61	618.89		28,432.66	1,012.45	29,445.11
Vermont	25,571.19	1,172.15	12.45	22.55	15.48		112.43	2,934.52	1,588.21		562.86	31,991.84	4,397.56	36,389.40
Virginia	63,497.25	2,001.12	37.84		240.06	16.75	5,174.20	9,233.33	8,158.79			88,359.34	24,442.46	112,801.80
Washington	24,167.92	5,188.02	201.40	107.23		46.28	2,157.28	6,811.95	3,710.54			42,390.62	10,701.49	53,092.11
West Virginia	46,076.56	2,199.69		20.04	35.86	25.00	1,236.05	3,165.62	6,281.82			59,040.64	33,244.60	92,285.24
Wisconsin	62,228.02	3,665.40	87.83			45.42	1,776.32	16,895.46	10,094.34			94,792.79	1,818.31	96,611.10
Wyoming	15,738.66	1,947.69	117.61	285.45		29.75	1,358.53	1,514.81	5,227.42	3,466.60		29,686.52	5,783.53	35,470.05
Total	2,401,836.42	157,575.40	6,174.31	4,985.13	11,027.99	14,428.71	85,939.45	326,946.45	331,059.93	48,274.01	5,633.79	3,393,881.59	646,805.83	4,040,687.42

[1] These unexpended balances by provisions of title I, sec. 9(a) of the Research and Marketing Act remain available for expenditure during the fiscal year ending June 30, 1951.

[2] Include allotments from the appropriation for fiscal year 1950 plus unexpended balances of allotments from appropriation for fiscal year 1949.

TABLE 9.—*Expenditures and funds available under the Research and Marketing Act of 1946, Title I, Section 9(b)3, for the year ended June 30, 1950*

Station	Expenditures												Unexpended balances [1]	Funds available [2]
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and reproduction	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Total expenditures		
Alabama	$12,804.56	$1,174.96	$104.59	$35.65	$98.91		$38.20	$566.83	$452.78			$15,276.48	$2,646.92	$17,923.40
Alaska														
Arizona	9,269.18	1,547.89	9.27	6.31		$4.00	28.00	951.57	420.59			12,236.81	813.19	13,050.00
Arkansas	12,323.59	1,896.29						837.97	1,159.07		$50.00	16,266.92	12,350.91	28,617.83
California	18,061.82	2,052.63	40.85	119.69	67.12	2,606.48	1,100.84	274.79		$16.26		24,340.48	2,624.30	26,964.78
Colorado	36,868.71	12,667.30	851.55	601.11	2,048.80	304.71	2,514.35	5,149.25	5,741.75	206.48	810.19	67,764.20	12,112.34	79,876.54
Connecticut:														
State														
Storrs	10,230.97	244.17				5.00	105.91	1,258.36	1,433.77			13,278.18	1,198.75	14,476.93
Delaware	2,250.00											2,250.00		2,250.00
Florida	5,399.00	6,649.81		2.00			30.86	183.18	63.45			12,328.30	2,002.19	14,330.49
Georgia	15,257.29	1,642.56	20.14	4.43	501.44	14.15	286.33	2,002.24	3,669.95	73.40		23,471.93	9,915.86	33,387.79
Hawaii														
Idaho	14,832.26	2,293.08	118.51	387.16			99.16	5,257.26	100.99	33.00		23,121.42	1,930.64	25,052.06
Illinois	19,172.61	1,945.26	16.23	11.54		934.75	230.24	1,267.85	1,804.43		286.29	25,669.20	23,486.16	49,155.36
Indiana	10,501.48	3,139.13	78.06	11.95	87.67		5.64	4,649.31	645.56	19,880.42		38,999.22	22,147.98	61,147.20
Iowa	22,227.43	6,738.74	88.00	214.87	954.23	406.41	2,470.73	16,981.76	4,380.40	2,000.00		56,462.57	19,373.41	75,835.98
Kansas	8,764.20	2,421.29		5.93			556.70	2,633.51	1,685.48			16,067.11	778.47	16,845.58
Kentucky	8,016.77	815.77		3.15					427.50			9,263.19	266.62	9,529.81
Louisiana	9,720.06	747.73	4.63	45.43		23.75	191.83	1,439.92	1,330.46	452.97		13,956.78	11,017.32	24,974.10
Maine	19,804.16	2,489.95	16.60	35.98	32.30	576.06	683.23	639.43	322.29			24,600.00		24,600.00
Maryland	5,839.87	1,055.11	31.24		250.00	374.69	790.36	3,505.58	2,492.74			14,339.59	960.20	15,299.79
Massachusetts	14,820.96						1,613.64					16,434.60	265.40	16,700.00
Michigan	13,281.50	4,315.83	7.00	69.78		79.54	121.05	688.18	163.50			18,726.38	12,099.12	30,825.50
Minnesota	15,233.32	4,390.92	36.69	17.00	348.13	818.44	2,033.63	4,148.67	1,430.61			28,457.41	7,808.71	36,266.12
Mississippi	29,143.30	3,383.31	33.69	92.72	106.05	1,043.33	121.32	2,651.61	263.35			36,838.68	9,861.80	46,700.48
Missouri	13,931.44	2,429.76	30.01	107.33		14.95	1,824.53	5,175.59	6,689.33		39.57	30,242.51	53.14	30,295.65
Montana	8,798.88	2,827.87		3.50			520.71	405.37				12,556.33	3,959.29	16,515.62
Nebraska	17,710.82	572.63	45.20	56.39			699.11	2,223.96	752.38			22,060.49	649.24	22,709.73
Nevada	3,114.27	1,224.02		20.50			6.75	664.46	1,650.00		120.00	6,800.00		6,800.00
New Hampshire	2,928.27	40.96		.10	395.00		380.35	356.28	199.04			4,300.00		4,300.00

New Jersey	19,193.89	1,168.85		9.52		4.32	171.14	224.83	3,129.01			23,901.56	5,350.26	29,251.82
New Mexico	11,910.51	1,684.99	28.72	67.50			273.60	6,143.01	742.41	23.10		20,873.84	810.04	21,683.88
New York:														
Cornell	33,146.64	3,778.85	23.01	249.55	164.14	6,439.96	4,351.37	4,928.32	4,298.06	11,686.79		69,066.69	17,256.40	86,323.09
State														
North Carolina	28,667.15	7,188.94	44.99	6.50	2,496.00	500.00	98.21	2,300.99	316.08			41,618.86	10,375.15	51,994.01
North Dakota	3,701.65	183.98		10.13	134.08		210.61	32.02			92.25	4,364.72	2,711.65	7,076.37
Ohio	16,024.72	1,235.02				107.25		1,317.62	96.00			18,780.61	3,466.93	22,247.54
Oklahoma	950.00	680.23				9.79	833.17	5,333.52	7,356.45	771.20		15,934.36	1,567.27	17,501.63
Oregon	30,326.25	4,255.56	88.44	265.20	307.42	175.47	1,653.58	2,729.31	1,854.54			41,655.77	5,024.65	46,680.42
Pennsylvania	10,714.23	1,809.72	5.35	6.40				4,185.74	7,748.45	3,894.29		28,364.18	10,521.39	38,885.57
Puerto Rico	2,745.56							546.09	208.35			3,500.00		3,500.00
Rhode Island	18,865.76	764.45	4.43				585.88	2,060.67	752.24			23,033.43	1,563.02	24,596.45
South Carolina	25,637.61	3,584.69	19.81	118.93	40.95		285.37	1,754.56	302.10			31,744.12	3,376.30	35,120.42
South Dakota	9,278.77	337.38	2.07				253.00	3,213.81	3,662.60			16,747.63	2,998.67	19,746.30
Tennessee	17,333.49	1,352.98	7.92	10.00			824.29	1,183.82	2,039.09			22,751.59	5,478.81	28,230.40
Texas	38,227.93	6,888.25	19.69	213.49	575.69	295.66	4,145.29	6,989.14	5,931.41	946.39		64,232.94	1,076.04	65,308.98
Utah	22,075.27	3,316.22	111.06	325.43		40.75	416.73	7,198.30	1,788.79	71.88		35,344.43	11,382.33	46,726.76
Vermont	1,179.41	443.99	75.50				62.22	2,653.14	712.43		3.60	5,130.29	1,156.88	6,287.17
Virginia	12,579.90	1,336.57		92.20			1,087.43	118.90				15,215.00	3,000.00	18,215.00
Washington	22,320.63	3,303.26	13.41	48.46			2,822.82	6,511.75	1,099.03			36,119.36	5,935.37	42,054.73
West Virginia	7,299.40	2,669.60	425.96			12.79	44.88	1,180.55	3,075.18			14,708.36	9,587.09	24,295.45
Wisconsin	13,009.61	2,155.42	31.57		46.65		2,459.69	5,753.73	3,572.89			27,029.56	4,376.34	31,405.90
Wyoming	8,392.90	3,921.03	4.88	21.44			345.22	1,534.62	995.04	186.60		15,401.73	979.18	16,380.91
Total	713,888.00	120,767.05	2,439.07	3,297.27	8,654.58	14,792.25	37,377.97	131,807.37	86,959.57	40,242.78	1,401.90	1,161,627.81	266,315.73	1,427,943.54

[1] These unexpended balances by provisions of title I, sec. 9(a) of the Research and Marketing Act remain available for expenditure during the fiscal year ending June 30, 1951.

[2] Include allotments from the appropriation for fiscal year 1950 plus unexpended balances of allotments from appropriation for fiscal year 1949.

TABLE 10.—*Expenditures from non-Federal funds for the year ended June 30, 1950*

Station	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and reproduction	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Total	Unexpended balances
Alabama	$498,374.88	$23,189.08	$5,980.69	$4,625.97	$14,188.02	$3,698.50	$53,337.02	$252,233.25	$88,697.39	$39,193.76	----------	$983,518.56	$342,328.89
Alaska	71,930.46	27.50	64.69	4.61	72.30	938.40	2,519.35	6,844.14	4,703.77	8,940.08	----------	96,045.30	26,299.08
Arizona	235,893.17	8,359.67	533.27	3,230.16	3,193.60	6,231.69	13,116.41	45,378.12	24,493.51	3,373.55	----------	343,803.15	----------
Arkansas	293,661.01	24,043.78	2,433.82	3,071.50	18,602.26	3,172.12	41,398.17	119,182.55	40,570.77	----------	$3,609.83	549,745.81	71,672.33
California	3,273,397.33	130,474.59	8,183.78	50,288.89	37,315.58	76,523.74	209,755.46	328,001.64	188,285.02	----------	----------	4,302,226.03	319,911.68
Colorado	250,581.09	11,971.67	4,969.42	4,364.42	17,046.90	4,880.74	14,022.06	84,505.82	41,407.11	4,317.97	5,856.22	443,923.42	165,823.39
Connecticut:													
State	257,528.46	2,310.89	216.94	2,736.24	6,623.39	6,534.23	12,626.25	23,645.67	15,959.46	3,384.82	----------	331,566.35	91,805.57
Storrs	194,522.62	2,364.24	211.55	12.85	338.65	1,465.93	2,288.30	31,931.86	7,912.73	255,500.00	----------	496,548.73	11,512.25
Delaware	112,309.47	5,000.80	675.78	3,687.87	3,993.51	21.82	8,315.67	75,484.89	10,266.73	1,540.00	----------	221,296.54	35,828.99
Florida	1,416,992.08	51,692.82	4,292.34	12,066.48	25,923.94	11,230.87	38,534.12	304,204.02	99,174.72	81,087.07	----------	2,045,198.46	743,241.04
Georgia	153,712.80	9,020.16	641.53	3,655.29	9,014.20	6,557.38	13,551.31	61,496.74	23,160.26	6,288.25	----------	287,097.92	75,492.65
Hawaii	385,466.16	5,852.06	826.54	2,375.87	5,525.05	5,138.84	13,294.24	51,243.96	19,937.19	1,047.25	----------	490,707.16	5,860.38
Idaho	239,417.50	6,420.55	4,625.00	7,225.00	10,100.00	1,500.00	3,600.00	61,890.83	71,390.33	26,565.00	----------	432,734.21	154,304.97
Illinois	1,161,516.70	70,000.00	----------	22,000.00	----------	44,000.00	----------	269,758.92	53,870.50	8,876.70	----------	1,630,022.82	----------
Indiana	875,190.47	39,882.33	8,668.58	11,153.10	22,529.45	80,772.12	115,322.16	461,834.09	113,066.87	62,414.17	----------	1,790,833.34	591,360.53
Iowa	778,829.13	29,616.93	3,477.51	5,050.20	24,693.72	19,966.20	----------	454,763.71	75,858.36	125,913.56	52,230.88	1,570,400.20	280,174.35
Kansas	319,779.43	10,529.66	2,559.08	3,187.11	7,716.73	181.19	39,537.23	91,696.29	123,411.80	90,746.77	----------	689,345.29	95,423.63
Kentucky	441,980.79	17,736.88	812.34	3,696.91	17,746.64	36,908.30	19,906.75	95,456.42	14,879.29	2,909.89	----------	652,034.21	----------
Louisiana	676,249.05	35,660.05	2,393.78	6,936.24	14,149.16	5,760.88	69,201.66	198,439.17	121,922.68	162,678.76	----------	1,293,391.43	----------
Maine	155,896.95	11,048.37	1,779.65	2,212.39	5,620.02	3,673.16	11,773.13	30,163.99	18,847.00	16,622.12	----------	257,636.78	32,345.71
Maryland	241,700.86	16,146.80	359.97	1,289.93	735.02	2,121.48	16,108.60	71,193.25	24,625.93	8,393.57	----------	382,675.41	100,935.13
Massachusetts	381,012.12	12,067.40	317.90	3,879.20	3,073.95	3,449.00	3,240.50	33,370.24	12,086.19	175.50	----------	452,672.00	23,858.53
Michigan	619,401.38	20,718.44	1,489.92	2,225.32	3,202.31	32,785.01	37,250.94	85,431.51	32,684.63	42,160.33	----------	877,349.79	107,932.37
Minnesota	1,065,277.79	19,384.97	6,239.69	9,116.26	23,627.55	2,994.93	110,606.34	269,227.75	60,378.12	14,395.20	----------	1,581,248.60	----------
Mississippi	520,832.11	17,133.65	8,030.03	6,630.89	16,345.26	7,681.12	58,658.78	273,075.29	119,711.64	93,919.68	----------	1,122,018.45	111,631.64
Missouri	270,555.87	14,210.69	2,694.66	2,565.24	9,696.68	24,714.49	28,874.44	120,424.46	51,209.57	9,978.26	----------	534,924.36	198,306.96
Montana	352,371.42	10,275.17	9,962.39	3,098.49	37,335.59	3,834.39	12,613.07	152,543.32	31,891.91	31,146.16	12,730.21	657,802.12	202,740.15
Nebraska	443,768.19	29,599.85	4,921.11	3,150.50	12,567.07	10,453.55	2,822.43	231,792.00	110,135.98	3,065.18	----------	852,275.86	60,565.67
Nevada	17,572.45	3,940.67	407.38	700.70	2,253.65	806.00	3,132.03	8,237.89	3,112.26	287.10	50.00	40,500.13	20,213.64
New Hampshire	37,142.71	2,819.10	89.48	445.21	73.00	186.33	382.61	5,598.14	6,897.74	----------	----------	53,634.32	4,210.54
New Jersey	682,804.83	24,794.84	1,134.67	16,978.66	35,241.40	11,597.07	27,100.75	156,659.29	47,131.68	----------	----------	1,003,443.19	3,670.77
New Mexico	135,893.84	2,317.08	448.92	640.98	5,028.06	2,348.15	6,018.17	24,831.47	12,662.72	36,350.79	3,988.69	230,528.87	68,362.27
New York:													
Cornell	1,567,121.79	33,577.07	3,802.49	16,018.43	122,020.58	6,989.07	52,626.32	272,512.15	109,017.54	14,863.36	----------	2,198,548.80	----------
State	604,595.04	9,670.84	1,205.49	4,589.76	12,535.47	11,461.38	9,219.27	75,976.31	44,946.00	11,014.96	----------	785,214.52	----------
North Carolina	795,318.69	28,757.27	3,022.97	8,808.53	12,836.31	15,797.19	72,294.67	122,005.27	128,733.31	23,255.63	----------	1,210,829.84	----------

North Dakota	277,541.15	8,795.09	1,230.39	1,488.48	23,090.31	8,036.54	32,841.88	74,305.02	49,117.93	181,425.62	7,295.76	665,168.17	97,483.17
Ohio	640,781.61	12,040.97	4,116.32	6,477.11	13,467.43	7,002.83	23,398.85	211,230.03	65,573.70	286,652.72		1,270,741.57	687,715.75
Oklahoma	474,282.81	25,351.90	3,488.45	3,821.70	12,186.71	8,903.56	22,572.01	206,847.33	119,147.06	62,853.39		939,454.92	164,625.07
Oregon	850,797.35	43,517.97	5,687.46	10,493.37	17,062.39	18,193.98	39,215.06	211,914.89	67,198.87		36,847.63	1,300,928.97	
Pennsylvania	660,852.93	23,410.65	1,590.46	2,486.27	13,400.52	13,233.17	9,516.21	133,291.07	36,442.07	24,675.83		918,899.18	75,929.75
Puerto Rico	367,739.45	6,221.11	1,276.03	2,565.62	10,367.80	2,490.58	21,898.81	60,881.35	19,281.46	99,939.78	337.32	592,999.31	227,907.97
Rhode Island	63,364.55	1,151.89	28.08	56.24		1,059.11	1,021.42	8,670.53	3,268.68			78,620.50	31,525.48
South Carolina	297,011.03	10,299.33	72.69	1,505.95	6,709.44	1,448.61	27,845.03	66,365.18	17,778.86	7,105.50		436,141.62	38,263.83
South Dakota	165,499.06	4,618.79	515.03	1,064.91	1,265.60	4,593.83	2,770.86	75,908.49	21,617.40			277,853.97	30,578.02
Tennessee	321,383.15	10,147.04	4,676.33	3,629.60	6,981.32	7,666.46	24,123.45	119,374.49	52,923.60	15,026.66		565,932.10	
Texas	1,114,134.78	29,394.19	3,088.50	13,357.82	27,685.57	4,979.94	329,474.86	220,781.27	236,644.31	65,585.11	28,771.55	2,073,897.90	845,493.47
Utah	224,003.84	14,599.72	2,240.22	2,488.21	8,363.13	2,135.80	8,166.63	58,594.23	19,721.01	12,593.36		352,906.15	53,493.28
Vermont	48,813.56	1,379.10	227.04	441.07	3,213.29	492.20	3,159.37	6,551.22	5,507.93	1,120.70	1,111.54	72,017.02	16,755.49
Virginia	375,643.22	25,482.10	1,742.29	6,180.15	8,890.76	3,735.83	17,957.76	72,522.39	49,752.06	120,728.66		682,635.22	83,627.31
Washington	931,489.79	42,147.11	7,178.04	6,942.69	13,826.55	10,590.55	37,949.46	217,694.54	122,550.93	34,656.31	36,099.59	1,461,125.56	
West Virginia	153,885.40	5,261.01	513.35	746.85	9,350.52	2,014.23	32,777.21	81,191.04	61,961.96	40,909.76		388,611.33	127,224.90
Wisconsin	1,472,789.00	28,989.00	3,323.00	2,415.00	6,829.00	8,213.00	52,161.00	294,132.00	25,719.00			1,894,570.00	
Wyoming	136,585.92	13,936.11	2,732.56	2,423.22	6,471.58	3,688.54	16,333.76	68,126.43	61,335.09	29,078.18		340,711.39	80,058.57
Total	28,105,197.24	1,047,358.95	141,199.60	300,303.46	730,126.94	564,854.03	1,826,231.84	7,139,415.92	2,988,582.63	2,172,757.02	188,929.22	45,204,956.85	6,506,495.22

TABLE 11.—*Summary by States of expenditures of the experiment stations for the year ended June 30, 1950*

Station	Federal-grant funds							Contractual Federal funds, Research and Marketing, Title II	Non-Federal funds	Grand total
	Hatch	Adams	Purnell	Bankhead-Jones	Research and Marketing Title I		Total			
					Sections 9(b)1–9(b)2	Section 9(b)3				
Alabama	$15,000.00	$15,000.00	$60,000.00	$96,152.81	$87,210.09	$15,276.48	$288,639.38	$12,812.46	$983,518.56	$1,284,970.40
Alaska	15,000.00	7,500.00	20,000.00	2,627.86	9,686.28		54,814.14		96,045.30	150,859.44
Arizona	15,000.00	15,000.00	60,000.00	15,499.36	30,823.22	12,236.81	148,559.39		343,803.15	492,362.54
Arkansas	15,000.00	15,000.00	59,775.40	74,282.76	91,272.42	16,266.92	271,597.50		549,745.81	821,343.31
California	15,000.00	15,000.00	60,000.00	95,542.61	99,044.97	24,340.48	308,928.06	2,070.00	4,302,226.03	4,613,224.09
Colorado	15,000.00	15,000.00	60,000.00	26,055.98	39,927.53	67,764.20	223,747.71		443,923.42	667,671.13
Connecticut:										
State	7,461.80	7,500.00	29,959.36	13,085.18	13,865.09		71,871.43		331,566.35	403,437.78
Storrs	7,500.00	7,500.00	29,990.89	12,786.01	19,435.74	13,278.18	90,490.82	6,734.23	496,548.73	593,773.78
Delaware	15,000.00	14,696.37	60,000.00	6,054.94	24,588.54	2,250.00	122,589.85		221,296.54	343,886.39
Florida	15,000.00	15,000.00	60,000.00	40,579.22	43,869.37	12,328.30	186,776.89	2,447.05	2,045,198.46	2,234,422.40
Georgia	15,000.00	15,000.00	60,000.00	101,476.80	117,494.88	23,471.93	332,443.61	21,963.18	287,097.92	641,504.71
Hawaii	15,000.00	15,000.00	59,951.33	10,269.39	29,581.14		129,801.86	2,879.77	490,707.16	623,388.79
Idaho	15,000.00	15,000.00	60,000.00	16,589.81	27,838.17	23,121.42	157,549.40		432,734.21	590,283.61
Illinois	15,000.00	15,000.00	60,000.00	100,946.87	103,106.26	25,669.20	319,722.33		1,630,022.82	1,949,745.15
Indiana	15,000.00	15,000.00	60,000.00	73,368.26	88,633.99	38,999.22	291,001.47	26,311.20	1,790,833.34	2,108,146.01
Iowa	15,000.00	15,000.00	60,000.00	74,752.37	89,887.30	56,462.57	311,102.24	21,938.96	1,570,400.20	1,903,441.40
Kansas	15,000.00	15,000.00	60,000.00	57,178.54	67,187.32	16,067.11	230,432.97	9,183.53	689,345.29	928,961.79
Kentucky	15,000.00	15,000.00	60,000.00	95,122.25	118,766.87	9,263.19	313,152.31		652,034.21	965,186.52
Louisiana	15,000.00	15,000.00	60,000.00	65,919.96	83,256.50	13,956.78	253,133.24		1,293,391.43	1,546,524.67
Maine	15,000.00	15,000.00	60,000.00	24,124.05	34,493.31	24,600.00	173,217.36	11,153.61	257,636.78	442,007.75
Maryland	15,000.00	15,000.00	60,000.00	35,297.74	43,607.96	14,339.59	183,245.29	2,497.85	382,675.41	568,418.55
Massachusetts	15,000.00	15,000.00	60,000.00	21,787.39	35,751.10	16,434.60	163,973.09		452,672.00	616,645.09
Michigan	15,000.00	15,000.00	60,000.00	85,827.73	88,516.03	18,726.38	283,070.14	24,881.22	877,349.79	1,185,301.15
Minnesota	15,000.00	15,000.00	60,000.00	66,813.91	85,627.55	28,457.41	270,898.87		1,581,248.60	1,852,147.47
Mississippi	15,000.00	15,000.00	60,000.00	84,569.98	116,654.66	36,838.68	328,063.32	24,653.73	1,122,018.45	1,474,735.50
Missouri	15,000.00	15,000.00	60,000.00	89,383.63	107,395.62	30,242.51	317,021.76		534,924.36	851,946.12
Montana	15,000.00	15,000.00	60,000.00	17,871.46	34,116.36	12,556.33	154,544.15		657,802.12	812,346.27
Nebraska	15,000.00	15,000.00	60,000.00	44,233.72	56,687.50	22,060.49	212,981.71		852,275.86	1,065,257.57
Nevada	15,000.00	15,000.00	60,000.00	3,190.40	21,738.58	6,800.00	121,728.98		40,500.13	162,229.11
New Hampshire	15,000.00	15,000.00	60,000.00	9,925.30	27,101.98	4,300.00	131,327.28		53,634.32	184,961.60

New Jersey	15,000.00	15,000.00	60,000.00	36,470.37	40,376.33	23,901.56	190,748.26	4,076.80	1,003,443.19	1,198,268.25
New Mexico	15,000.00	15,000.00	60,000.00	16,935.36	36,353.63	20,873.84	164,162.83	----------	230,528.87	394,691.70
New York:										
Cornell	13,499.98	13,500.00	53,827.80	99,201.85	104,002.17	69,066.69	353,098.49	5,972.52	2,198,548.80	2,557,619.81
State	1,491.27	1,493.75	5,998.57	10,995.95	8,822.12	----------	28,801.66	15,578.59	785,214.52	829,594.77
North Carolina	15,000.00	15,000.00	60,000.00	123,766.51	147,680.87	41,618.86	403,066.24	----------	1,210,829.84	1,613,896.08
North Dakota	15,000.00	15,000.00	60,000.00	28,147.42	42,295.50	4,364.72	164,807.64	----------	665,168.17	829,975.81
Ohio	15,000.00	15,000.00	60,000.00	109,337.26	76,651.12	18,780.61	294,768.99	6,862.76	1,270,741.57	1,572,373.32
Oklahoma	15,000.00	15,000.00	60,000.00	78,367.16	82,438.94	15,934.36	266,740.46	3,270.40	939,454.92	1,209,465.78
Oregon	15,000.00	15,000.00	60,000.00	26,588.72	45,549.19	41,655.77	203,793.68	4,940.10	1,300,928.97	1,509,662.75
Pennsylvania	15,000.00	15,000.00	60,000.00	157,876.48	87,724.94	28,364.18	363,965.60	----------	918,899.18	1,282,864.78
Puerto Rico	15,000.00	15,000.00	59,990.54	62,011.82	84,107.75	3,500.00	239,610.11	1,626.46	592,999.31	834,235.88
Rhode Island	15,000.00	15,000.00	60,000.00	2,857.19	18,959.89	23,033.43	134,850.51	----------	78,620.50	213,471.01
South Carolina	15,000.00	15,000.00	60,000.00	69,224.19	84,323.35	31,744.12	275,291.66	----------	436,141.62	711,433.28
South Dakota	15,000.00	15,000.00	60,000.00	27,733.01	34,799.61	16,747.63	169,280.25	----------	277,853.97	447,134.22
Tennessee	15,000.00	15,000.00	60,000.00	89,992.09	101,826.69	22,751.59	304,570.37	825.13	565,932.10	871,327.60
Texas	15,000.00	15,000.00	59,999.95	173,212.42	186,108.75	64,232.94	513,554.06	9,098.63	2,073,897.90	2,596,550.59
Utah	15,000.00	15,000.00	60,000.00	12,170.15	28,432.66	35,344.43	165,947.24	----------	352,906.15	518,853.39
Vermont	15,000.00	15,000.00	59,902.69	12,072.24	31,991.84	5,130.29	139,097.06	----------	72,017.02	211,114.08
Virginia	15,000.00	15,000.00	60,000.00	82,941.86	88,359.34	15,215.00	276,516.20	----------	682,635.22	959,151.42
Washington	15,000.00	15,000.00	60,000.00	38,797.09	42,390.62	36,119.36	207,307.07	6,586.73	1,461,125.56	1,675,019.36
West Virginia	15,000.00	15,000.00	60,000.00	65,169.05	59,040.64	14,708.36	228,918.05	2,500.00	388,611.33	620,029.38
Wisconsin	15,000.00	15,000.00	60,000.00	70,152.59	94,792.79	27,029.56	281,974.94	1,316.45	1,894,570.00	2,177,861.39
Wyoming	15,000.00	15,000.00	60,000.00	7,829.36	29,686.52	15,401.73	142,917.61	----------	340,711.39	483,629.00
Total	764,953.05	757,190.12	3,019,396.53	2,863,166.43	3,393,881.59	1,161,627.81	11,960,215.53	232,181.36	45,204,956.85	57,397,353.74

TABLE 12.—*Summary by classification of expenditures of the experiment stations for the year ended June 30, 1950*

Account	Hatch Act	Adams Act	Purnell Act	Bankhead-Jones Act	Research and Marketing Act, Title I		Total	Contractual Federal funds, Research and Marketing Act, Title II	Non-Federal Funds	Grand total
					Sections 9(b)1 and 9(b)2	Section 9(b)3				
01 Personal services	$618,368.93	$657,682.85	$2,523,265.01	$2,251,117.86	$2,401,836.42	$713,888.00	$9,166,159.07	$137,172.11	$28,105,197.24	$37,408,528.42
02 Travel	19,856.73	7,153.32	66,883.37	49,392.18	157,575.40	120,767.05	421,628.05	18,395.65	1,047,358.95	1,487,382.65
03 Transportation of things	834.55	856.84	2,852.15	3,175.50	6,174.31	2,439.07	16,332.42	601.14	141,199.60	158,133.16
04 Communication services	5,978.77	238.17	3,083.30	2,682.69	4,985.13	3,297.27	20,265.33	423.61	300,303.46	320,992.40
05 Rents and utility services	5,250.97	1,194.42	12,233.26	10,099.03	11,027.99	8,654.58	48,460.25	274.69	730,126.94	778,861.88
06 Printing and reproduction	38,577.75		29,766.07	14,170.40	14,428.71	14,792.25	111,735.18	1,300.57	564,854.03	677,889.78
07 Other contractual services	9,248.57	6,747.18	34,063.76	41,215.51	85,939.45	37,377.97	214,592.44	4,199.58	1,826,231.84	2,045,023.86
08 Supplies and materials	34,750.78	47,779.02	204,147.55	298,454.58	326,946.45	131,807.37	1,043,885.75	21,167.95	7,139,415.92	8,204,469.62
09 Equipment	29,313.53	32,251.88	124,624.27	161,338.70	331,059.93	86,959.57	765,547.88	36,460.28	2,988,582.63	3,790,590.79
10 Lands and structures (contractual)	17.69	196.42	8,333.11	23,094.30	48,274.01	40,242.78	120,158.31	12,185.78	2,172,757.02	2,305,101.11
11 Contributions to retirement	2,754.78	3,090.02	10,144.68	8,425.68	5,633.79	1,401.90	31,450.85		188,929.22	220,380.07
Total	764,953.05	757,190.12	3,019,396.53	2,863,166.43	3,393,881.59	1,161,627.81	11,960,215.53	232,181.36	45,204,956.85	57,397,353.74

TABLE 13.—*Expenditures and allotments under the Research and Marketing Act of 1946, Title II, for the year ended June 30, 1950*

Station	Expenditures											Unexpended balance	Funds available [1]
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and reproduction	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Total expenditures		
Alabama	$2,836.07	$138.60	$99.40		$21.69		$139.84	$1,604.46	$6,636.62	$1,335.78	$12,812.46	$4,387.54	$17,200.00
California	2,070.00										2,070.00		2,070.00
Connecticut:													
Storrs	5,700.00	508.75							525.48		6,734.23	265.77	7,000.00
Florida	1,874.98	567.99						4.08			2,447.05	7,552.95	10,000.00
Georgia	16,991.32	2,159.55		$18.73	128.00	$654.63	1.50	1,679.30	330.15		21,963.18	7,236.82	29,200.00
Hawaii	237.24	2,353.76						41.65	247.12		2,879.77	3,120.23	6,000.00
Illinois												7,200.00	7,200.00
Indiana	8,460.32	1,524.16	2.00				162.66	816.78	4,495.28	10,850.00	26,311.20	5,688.80	32,000.00
Iowa	18,021.54	658.71	5.48	28.91		145.64	24.00	709.49	2,345.19		21,938.96	2,032.50	23,971.46
Kansas	7,281.11	725.53	1.77				59.83	708.62	406.67		9,183.53	816.47	10,000.00
Maine	3,316.01	2,823.89	450.84	122.70		125.00	704.26	1,990.17	1,620.74		11,153.61	346.39	11,500.00
Maryland	2,399.46	75.35					23.04				2,497.85	102.15	2,600.00
Michigan	20,291.62	1,675.60	4.63	21.83		115.93	158.56	145.92	2,467.13		24,881.22	14,355.36	39,236.58
Mississippi	16,092.73	584.42	11.22	89.43		96.50	194.76	4,807.96	2,776.71		24,653.73	12,765.40	37,419.13
New Jersey	363.51	42.15	21.27				1,438.40	1,165.05	1,046.42		4,076.80	1,923.20	6,000.00
New York:													
Cornell	5,222.29	216.23					34.37	206.82	292.81		5,972.52	4,327.48	10,300.00
State	2,779.28	248.35		71.74	25.00		1,129.40	3,257.32	8,067.50		15,578.59	770.97	16,349.56
Ohio	2,775.17	533.12						3,079.31	475.16		6,862.76	3,837.24	10,700.00
Oklahoma	1,068.48	412.94						293.61	1,495.37		3,270.40	1,729.60	5,000.00
Oregon	3,843.37	539.06		56.17		162.87	27.78	53.35	257.50		4,940.10	1,059.90	6,000.00
Puerto Rico	439.01						9.50	44.40	1,133.55		1,626.46	8,373.54	10,000.00
Tennessee	666.60	141.93						16.60			825.13	474.87	1,300.00
Texas	6,906.58	1,850.94	1.88				56.68	276.17	6.38		9,098.63	13,417.10	22,515.73
Washington	3,883.66	583.31	2.65	14.10	100.00		35.00	133.51	1,834.50		6,586.73	8,163.27	14,750.00
West Virginia	2,500.00										2,500.00		2,500.00
Wisconsin	1,151.76	31.31						133.38			1,316.45	1,956.88	3,273.33
Total	137,172.11	18,395.65	601.14	423.61	274.69	1,300.57	4,199.58	21,167.95	36,460.28	12,185.78	232,181.36	111,904.43	344,085.79

[1] Include allotments from the appropriation for fiscal year 1950 plus unexpended balances of allotments from appropriation for fiscal year 1949.

SUBJECT INDEX, 1950

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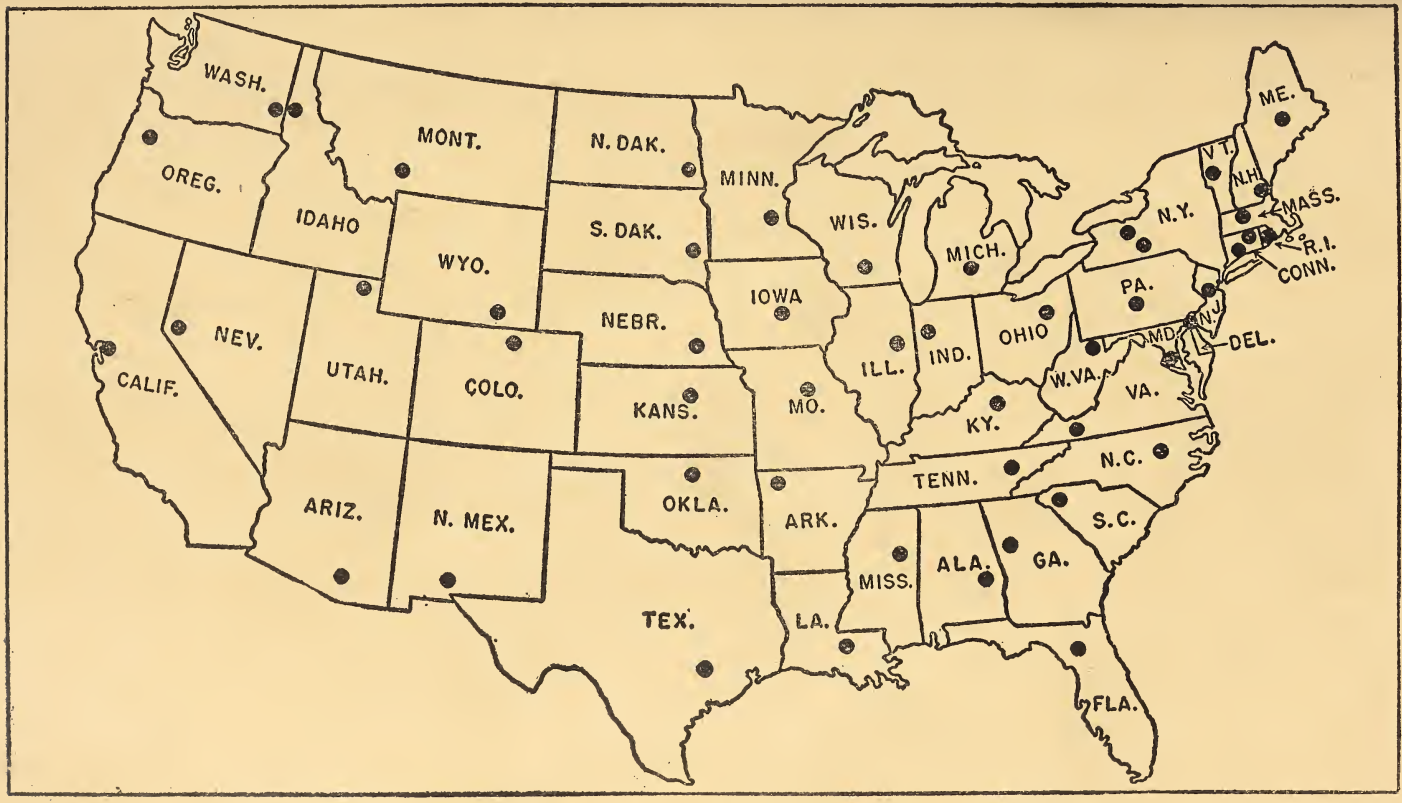

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